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GEOGRAPHIC ASPECTS OF PUMP IRRIGATION ON THE NEBRASKA LOESS PLAIN IN RELATION TO SUBSURFACE PHYSIOGRAPHY

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THE Nebraska Loess Plain is a roughly triangular area from the Big Blue River westward to beyond Holdrege (see Fig. 1). The length from east to west is approximately 150 miles and the north–south distance at the broad side of the triangle is about 80 miles. The area is estimated at 8,000 square miles, with the general characteristic of broad, flat plains with shallow streams and local surface depressions referred to as ponds. The Little Blue and the Big Blue Rivers are the main drainage outlets and the only permanently flowing streams within the area. The upland slopes east-southeastwardly at an average gradient of 6.5 feet per mile. The local modifications of the upland surface of this generally flat plain are low hills, presumably built by wind action, and some shallow drainageways that serve as outlets after heavy rains. The meandering drainage courses have low gradients and shallow channels. Slopes are so gentle that in most instances tillage farming is unobstructed. The soil is rich in the soluble minerals essential to crop production and in its virgin state is well supplied with organic content. As a whole, the Nebraska Loess Plain may rightly lay claim to as high a percentage of tillable land as any area of like size in the United States.

Nevertheless, much of this area does not give evidence of high agricultural prosperity. Farmsteads show signs of adversity in their high percentage of houses and barns sadly in need of paint, the lack of well-kept windbreaks, and the greater-than-average percentage of decrepit automobiles of ancient design. In a land of excellent soil, free from stumps and boulders, with nearly every acre tillable and ample transportation facilities, why there is not a high degree of agricultural prosperity is a question raised by laymen and inquiring scientists alike. The answer is not simple, but the foremost factor is the lack of dependable moisture when most needed.

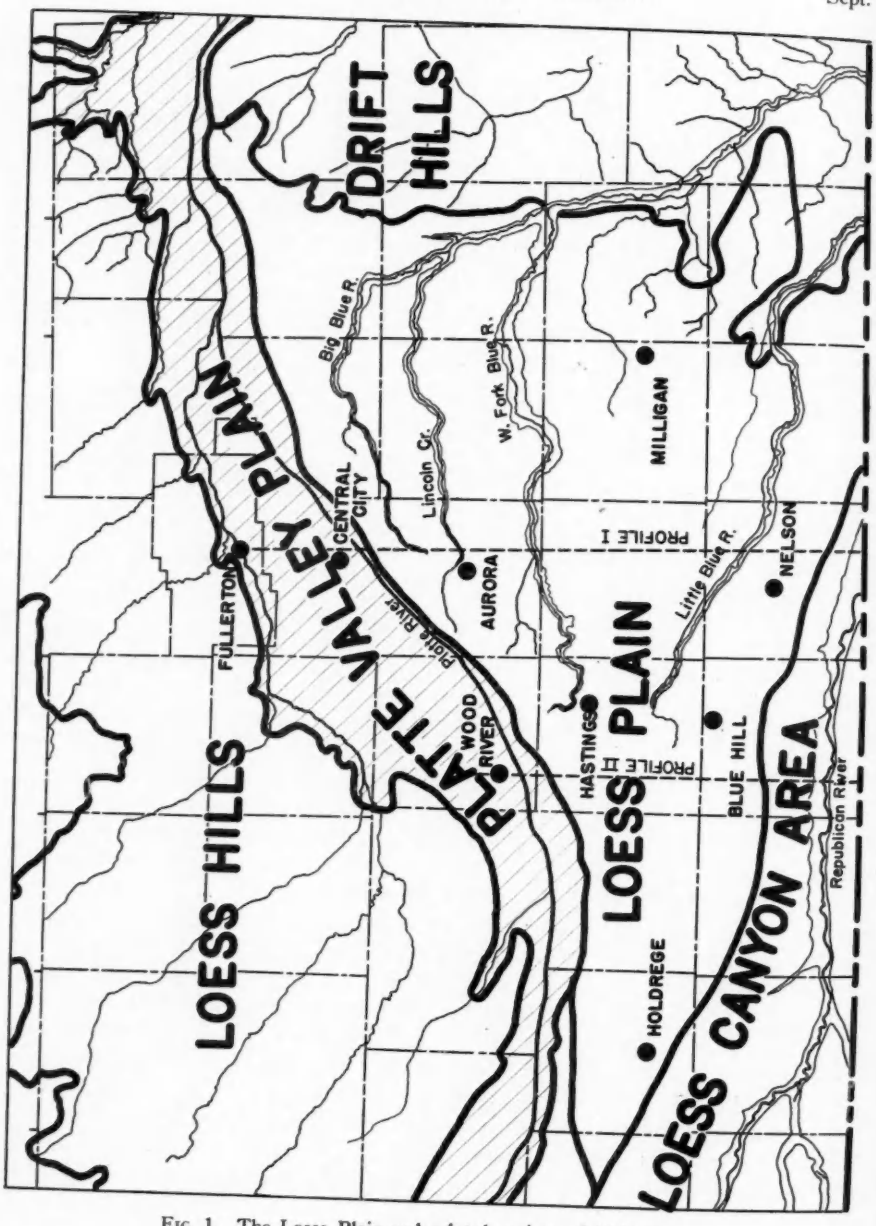

FIG. 1. The Loess Plain and related regions of Nebraska.

VARIABILITY OF RAINFALL

The average annual rainfall ranges from 28 inches in the eastern part to 23 inches in the western, and in all sections the distribution by months is generally favorable for the grains and grasses of the region. Variability, however, in terms of both years and months, is excessive in view of the slim margin of safety that prevails. Since this aspect has been well discussed in several published papers, just an illustration or two will suffice here.[1] The annual precipitation for this general area has ranged from 44 inches to 16 inches in the eastern part and from 44 to 14 inches in the west. The critical months for wheat and corn are May–June for the former, and July–August for the latter. When moisture is then deficient, low crop yields or even total failures result, although the other months may have normal or nearly normal rainfall. Those are the periods when the addition of some water by irrigation spells the difference between success and failure in economic agricultural production. Inasmuch as stream-water is out of the question for most of the upland, and since much of the area is underlaid by sand and gravel beneath the loess and below the water table, pump irrigation has been hailed as the solution.

LOCAL VARIATIONS IN SUBSURFACE WATER SUPPLIES

Early observations led to the impression that the bedrock surface was a fully-developed peneplain with but little relief, and that it was mantled with sands and gravels deposited during Pleistocene times in regular succession without any significant unconformities.[2] Drilling for ground-water supplies available in such volumes as to sustain rotary pumps throwing thousands of gallons per minute has revealed prominent differences. In general, the lift necessary is 100 feet or more, but the flowage that can be pumped varies from below 100 gallons to several thousand gallons per minute. In some places no available water is reached above the bedrock, while in others the supply is sufficient to meet the needs of cities of over 5,000 population; and in one case, that of Hastings, Nebraska, well water supplies a population of more than 16,000. The abundant supply of high-quality well water was a major factor in selecting the vicinity of Hastings as the site for one of the largest ammunition depots for the U. S. Navy. In contrast with Hastings, in the vicinity of Nelson, the Niobrara Chalk Rock is found exposed along shallow valley-sides with no sands separating it from the loess mantle. In consequence of this unconformity there is at Nelson but little available ground water in the mantle rock zone, not even enough in the summit area to meet the pumping supply needed to keep windmills in operation.

[1] See, for example, Van Royen, William, "Prehistoric Droughts in the Central Great Plains," *Geogr. Rev.*, Vol. 27, 1937, pp. 637–50; Kincer, J. B., "Is the Climate of the Great Plains Changing," *Twenty-Eighth Annual Report, Nebraska Crop Growers' Association*, Lincoln, 1937, pp. 58–68; and Lackey, Earl E., "Annual Rainfall Variability Maps of the United States," *Monthly Weather Review*, July, 1939, p. 201.

[2] Condra, G. E., Geologic Phases of Soil Erosion and Control in Nebraska, *Paper No. 6*, Nebraska Geological Survey, 1934, p. 6.

Although ridges of bedrock do not anywhere protrude above the flat upland surface of the Nebraska plain, in a number of places they mark subsurface topographic highs that reach their summit levels more than a hundred feet above the subsurface depressions or basins between them. While details are still incomplete, test wells made under the direction of the Nebraska Conservation Survey in cooperation with the U. S. Geological Survey have provided evidence that the pre-Pleistocene drainage was largely toward the southeast, and that it developed broad, gently sloping valleys where shales were the uppermost bedrock layers and narrow valleys where harder bedrock, such as limestone, prevailed. Upon the uneven bedrock topography thus developed, clastic sediments were dropped by the eastward-flowing streams whose outlets were blocked by the advances of continental ice sheets.

The periods of deposition are marked by alternating bodies of gravel, sand, and clay. That the stages of Pleistocene deposition were coincident with or followed by periods of erosion is evidenced by the extensive unconformities that have been traced through exposures in valley-sides, in railway cuts, and in well logs. That during the erosion stages the streams cut fresh channels is evidenced by strings of gravel deposits now traced in the subsurface sands. However, buried soil lines that long have been recognized as local features are now known to be individually extensive, and they give evidence of long periods of stable surface conditions wherein erosion failed to destroy the then-existing uplands. Thus is the complex physiography of the flat plains gradually becoming revealed as the detailed field work continues.

In the central part of Nebraska some of the lower Pleistocene formations have been found to be continuous under the Platte River flood plain. There the bedrock under the flood plain and under the southern upland is at such depths as to make possible the movement of subterranean water out of the Platte Plain into and under the upland loess plain. Since the channel of the Republican River in southern Nebraska lies from one hundred to three hundred feet below the channel of the Platte, the idea of extensive underflow from the Platte to the Republican early gained considerable credence. The flat surface topography, gently sloping southeastward, together with the lack of evidence as to bedrock topography and as to structure of the mantle rock, were factors favorable toward accepting the idea of Platte River underflow southeastward into the Blue and the Republican. Thus the belief developed in the minds of many that the underground waters of the Loess Plain were so abundant in the gravels and coarse sands as to supply ample irrigation waters throughout for perhaps 90 per cent of the land. Since in most years from 2 to 6 inches of water properly applied at the critical times spell the difference between low crop returns and high yields, the lift of water even in excess of 100 feet may prove economically advantageous.

STREAM GRADIENTS AND UNDERFLOW

Two factors have been found to be limitations to the idea of general success earlier

held. The first and most obvious is that the downstream gradient of the channel of the Platte is as great as or greater than the direct gradient southward to the Republican or the Blue (Fig. 2). For example, near Central City on the Platte Plain the

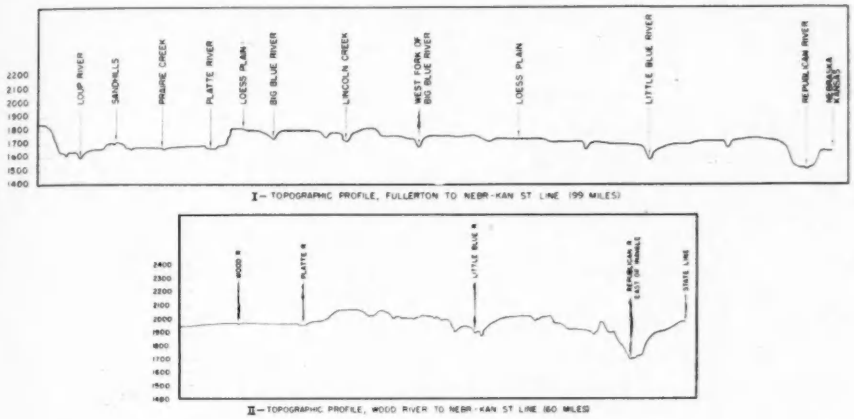

FIG. 2. Topographic profiles from the Platte valley to Kansas line. (For location of profiles see Figure 1.)

gradient downstream is 6.45 feet per mile, while the gradient southward to the Republican is but 5.66 feet per mile. Farther westward in the vicinity of Wood River we find that the gradients are nearly equal downstream and southward. There the downstream gradient of the Platte channel is 6.92 feet per mile, and the gradient southward to the Republican channel at 270 feet lower altitude is but 6.11 feet per mile. Under the conditions just given, that some recharge of the underflow of the Loess Plain occurs by waters from the Platte is not questioned, but in view of the higher gradients downstream than southward under the Loess Plain it seems unlikely that the recharge can be either continuous or universal.

The second factor is the unconformity now known to be characteristic of the contact of the mantle rock with the surface of the bedrock in the loess plains area. Bedrock makes up the lower parts of the north valley-side along the Republican where it rises 20 to 50 feet above the flood plain, thus lowering still further the gradient of open-textured material except for a few tributaries that have been incised through the loess-capped upland into the bedrock. With the bedrock ridges rising into the upper reaches of the mantle rock, as they are known to do near Blue Hill, Nelson, and Milligan, the existence of large supplies of underground water in the lower Pleistocene, replenishable throughout the Loess Plain by underflow from the Platte, is open to question. There seems to be no reason to doubt that recharge does occur in substantial quantities in some places, especially in the basin aspects of the

bedrock peneplain, for instance at Holdrege, Hastings, and Aurora, and perhaps at other places.[3] From these basins the bedrock surfaces rise southward and eastward, thus retarding or obstructing the flow in those directions. Recharge of ground water lost through seepages, springs, and direct or indirect evaporation occurs from rainfall within the area as well as from replenishment from the Platte valley, and perhaps to some extent by artesian pressure from sandy layers of bedrock.

THE RÔLE OF SUPPLEMENTAL IRRIGATION

The need for supplemental irrigation is generally conceded. The yields of corn in this area are not more than 50 per cent as large as in Iowa, where the soil in itself is no more productive than that of the Loess Plain, but rainfall is greater and more dependable. During the season of 1946, a record-breaking season for most of the corn-belt states, yields of 100 bushels per acre on the Loess Plain were not uncommon where supplemental irrigation was practiced, whereas even in the eastern part of the plain where the rainfall for 1946 was about 29 inches, a figure slightly above normal, the average yield was but 30 to 40 bushels on the non-irrigated upland fields. The highly profitable return under pump irrigation is almost certain to lead to rapid expansion of well installation, an expansion already pronounced but growing at an accelerated rate.

The sinking of irrigation wells is still largely on a wildcat, non-scientific basis. While this practice reveals data of scientific value and therefore has its commendable features, sufficient data have been assembled by the Conservation Water Survey to serve as guides to depth of penetration and to probability of available flow for most sections of the plains. The complexities of structure of the regolith have become accepted by all who have studied the evidence in the field. That the surface of the buried bedrock is one of considerable relief is likewise evident. These conditions serve to emphasize the imperative need for further work whereby the details of subsurface structure of the mantle rock and the topography of the deeply covered bedrock may become known.

The need for judicious use of the extensive ground-water resources of the Loess Plain has become clearly evident as a result of long-continued study of the basic physical features of the area.[4] There are large quantities of available water throughout much of the area, while elsewhere, particularly on the buried divides, the water available for pump irrigation is slight or even wanting. The sinking of expensive wells in such areas is an economic waste and can be avoided in sections now known to exist, although evidence may be lacking in other areas still awaiting detailed investigation.

[3] Lugn, A. L., The Pleistocene Geology of Nebraska, *Bulletin No. 10,* Nebraska Geological Survey, 1935, *pp.* 35–6.

[4] Bengtson, Nels A., "Is Rainfall in the Great Plains Decreasing?" *Twenty-Sixth Annual Report, Nebraska Crop Growers Association,* Lincoln, 1935, pp. 56–66; Visher, S. S., "Maps of Percentage Frequencies of Very Dry, Moderate, and Very Hot Months," *Monthly Weather Review,* March, 1944, pp. 63–70.

LAND USE CHANGES ATTRIBUTABLE TO IRRIGATION

The repercussions of the introduction of pump irrigation upon the Loess Plains uplands are felt along several lines. In the first place, irrigation farming, even on a supplementary basis, emphasizes intensive agricultural practices rather than the extensive type that has been in the ascendancy since the turn of the century. Forty years ago the farms averaged less than 160 acres per farm unit, now they average more than twice that size. The reason for the change, as is well recognized, is mechanization of farming operations. Trucks and tractors have displaced horses and mules. Social and economic results have been pronounced. Rural population has declined, villages and towns have been reduced from busy market places to a store or two, a filling station and garage, and an elevator. Country schools, formerly with 25 to 40 pupils, have simmered down to 5 or 6; country churches have been abandoned, leaving only the adjacent cemeteries as tokens of a more active past. The introduction of supplementary well-irrigation will tend to reverse the trend of the declining rural population in this section of the state, and with this reversal a long chain of constructive results will inevitably follow.

In the practice of supplemental irrigation farming we already see two other trends setting in; one, the greater emphasis upon feeding livestock since both feed and forage are quite assured, and, second, the increased introduction of legumes and the application of commercial fertilizers to restore the nitrogenous content of the soil. The expansion of acreage tilled by the individual farmer that has characterized the prevalent mechanized farming has reduced not only the number of rural farmsteads but also the number of home flocks of cattle and swine, and has thereby also reduced the application of farmyard manure fertilizer to the land. This practice tends toward serious reduction of the organic content of the upper soil layers, a practice that reduces the tilth of the soil with adverse effects upon its productivity. Another change under way is a gradual realization of the need for replenishing the nitrogenous content of the soil if the large yields made possible by irrigation are to be realized. Since legumes serve that purpose their increasing usage is readily understood. It has been found that the heavy yields produced at the outset by irrigation of upland farms are followed within a few years by reduced yields, and that this can most quickly be overcome by the judicious use of commercial nitrogenous fertilizers. Thus a new practice has developed in a region whose soil was formerly deemed so fertile as to make unnecessary the use of commercial fertilizers for at least another century.

The Loess Plain, in common with other areas of the Great Plains within the transition belt from humid to semiarid conditions, has been a typical pioneer belt since its early settlement in the seventies. The first crop plantings were made with seed brought from the more humid states east of the Mississippi. In wet years fairly good yields were produced, but the hopes thus raised soon gave way to despair with the drier years and failures that followed. Soon people came to realize the need of crops better adapted to lower rainfall conditions, and the introduction of varieties

from areas of low rainfall in Europe and Asia led to more satisfactory returns. Experimental work with breeding resulted in further improvement. All these, however, tended to emphasize successful farming on a basis of moderate yields on many acres, and thus they led to extensive mechanized farming with its attendant social and economic dislocations. The need for additional water as well as the need for better use of local rainfall remained as problems still to be solved if larger returns per acre were to be obtained.

THE "PIONEER PERIOD" NEARING ITS CLOSE

The scientific work now in progress, a phase of physiographic research that in its early stages seemed to have but slight probability of economic connotation, may lead to results that will mark the present as the closing chapter of the pioneer-belt era. The application of supplemental water to crop acreage through well-irrigation must be based on the physiographic conditions that prevail in order to insure permanency of supply. If the conservation of water supplies and of soil be practiced on a scientific basis, together with selection of crops adapted to the locale, the Loess Plains of Nebraska will become an area of dependable, greatly increased output of agricultural products—moderate even in dry years, and large in years of normal or greater rainfall. Stable production with reduced fluctuation in crop yields will minimize economic crests and troughs and go far toward establishing social stability in an area of increasing instead of decreasing rural population. These responses to an integrated program of physiographic research, together with studies of soils, crops, and economic adaptations, will mark the end of the pioneer period. Thus the development of dependable production induced by supplemental well irrigation will reduce or eliminate the economic hardships characteristic of the past.

THE POLITICAL RIVALRY OF PÁTZCUARO AND MORELIA, AN ITEM IN THE SIXTEENTH CENTURY GEOGRAPHY OF MEXICO

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THE promise of quick wealth lured the Spaniards into the New World. As it was fulfilled generously for a few, it encouraged great numbers of others to explore remote, sometimes unknown, often dangerous regions. The impact upon such regions was twofold. In some places native societies were obliterated or drastically altered; in others a new society was established where there had been either little or no permanent settlement previously. Thus the settlement pattern of the New World was radically changed during the sixteenth century, the period of time in which the theme of precious metals was the most notable.

It should be observed at the outset that the effects of newly gained mineral wealth extended far beyond the regions of mining. It is with such a region that this paper is concerned, a part of the present state of Michoacán. (Fig. 1.)

Michoacán, located due west of Mexico City, was a political unit of importance before the Spaniards knew of the Americas.[1] It submitted to Spanish authority without a struggle and became, with some additions of territory, under Spanish civil and ecclesiastical administration, the province of Michoacán. At the end of the period of Spanish control it emerged, with reduction to approximately its pre-Columbian size, as the present state of Michoacán.

It is obvious that the choice of a capital city for such an important area would be a matter of serious decision, especially as the native capital, the Indian city of Tzintzuntzan, was considered unfit by the Spaniards. If the Spaniards could have agreed upon a site for the new capital as readily as they agreed upon the insufficiency of the old, a half-century of local turmoil might have been avoided. The struggle centered itself in the northern part of the state, in and around the area settled by Tarascan Indians. (Fig. 2.)

FACTORS OF SITE AND SITUATION

Here there are two clearly distinguishable regions of land forms, peoples, and economies. One is a part of a volcanic range that traverses Mexico south of the twentieth parallel. The roughly east-west direction of these mountains is sharply different from that of the mountains to the north of this parallel which strike northwest-southeast. The difference in trend is only one of the differences in land forms

[1] Stanislawski, Dan, "Tarascan Political Geography," *American Anthropologist*, Vol. 49, No. 1 (Jan.–Mar., 1947), pp. 46–55. Note map facing p. 46 for area of Tarascan dominance.

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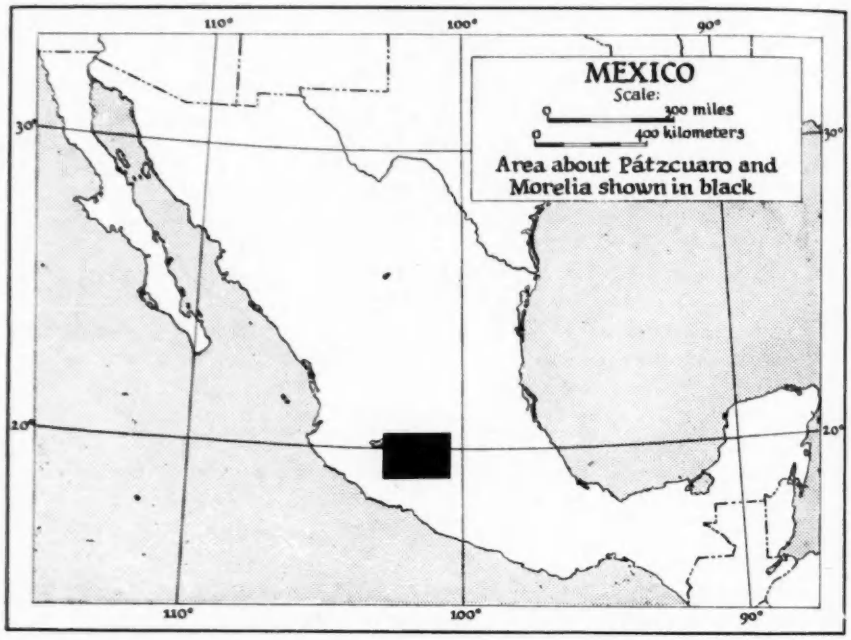

FIG. 1. Orientation of the Pátzcuaro-Morelia area, State of Michoacán, Mexico.

between the regions which are roughly separated by the parallel of twenty degrees north latitude. To the north the dominant process shaping the form of the land is one of degradation. To the south the reverse is true and the topography is due to the heaping-up of volcanic materials in great piles, high above the general level of the plateau. The result of the vulcanism is a varied region of peaks, plateaus, and hills, interspersed with mountain valleys. Within Michoacán the dissected volcanic cone of Tancítaro stands as the southwest outlier and as the highest peak of the state (3,860 M). It looks south, directly down into the Balsas Lowland. About thirty-five miles north of Tancítaro stands another such cone, Patamban (3,750 M), only slightly less impressive, which is the northwesterly outlier of the volcanic region within the state. This towers over the northern valleys of Tangancícuaro and Zamora.

From these two peaks a belt of mountains extends eastward, becoming widest at the longitude of the city of Tacámbaro (101° 20″ W). East of Tacámbaro the region narrows and runs diagonally toward the north corner of the state, where it meets the great volcanic mass which extends far to the north and south of the Nevado de Toluca in the state of Mexico.

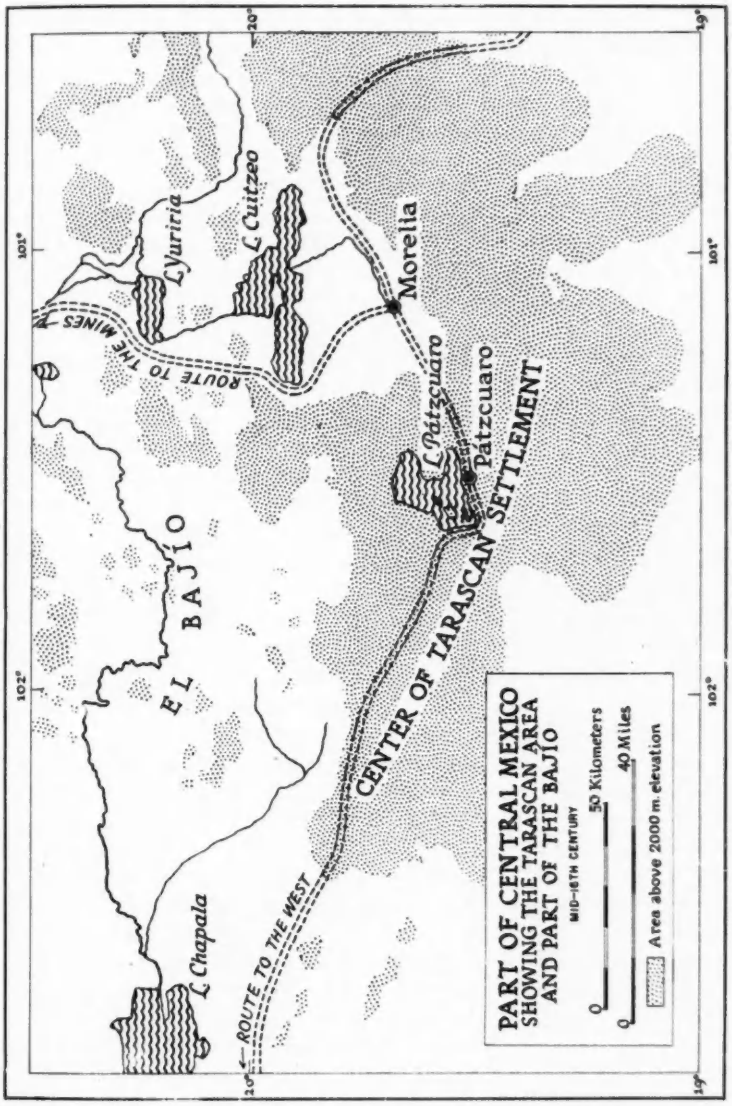

FIG. 2. The Tarascan area and part of the Bajío, central Mexico, mid-sixteenth century.

The average altitude is due both to the general height of the plateau at this latitude (5,000 feet) and to the quantities of volcanic materials deposited upon it.

This rugged volcanic region has but small areas of level land, such as those in narrow valley-bottoms and those formed in the broader beds of early lakes, into which the alluvium was carried and laid out in smooth layers.

The vulcanism that formed the region is not completely a thing of the past, for less than two centuries ago the Volcan de Jorullo was lifted above the general level of the relatively flat lands of the sugar hacienda where it was formed. The present decade has seen the birth and growth of the spectacular Mt. Paricutin.

The slopes of these ranges in Michoacán, covered with red volcanic soils, have been cultivated by Tarascan Indians since long before the time of the Conquest. This is the site of Pátzcuaro. (Fig. 3.)

FIG. 3. "Tarascan" hill land.

The second major landform area is that of the Bajío. This, like the transverse volcanic mountains, is part of a great area that continues far beyond the boundaries of the present state of Michoacán. North Michoacán is part of it, for from the northern edge of the volcanic heights there is a relatively short descent into this great, fertile, predominantly level area. Beyond the state borders the Bajío extends into Guanajuato, Querétaro and Jalisco. Its geomorphology is due in large part to blocked drainage and an early great lake into which tremendous amounts of fine sediments were washed from the slopes above. For the most part it lies between five and six thousand feet elevation. In a southern extension of this area is situated Morelia, the present capital of the state and the sixteenth-century rival of Pátzcuaro.[2] (Fig. 4.)

The Tarascan area was known at the time of the Spanish conquest of Mexico as a place of attraction and of possible profit. Cortés knew from the outset that these hill lands were the seat of a well-organized, productive, prosperous native state and, as was his habit, immediately appropriated the mineral sites for himself, granting lesser prizes to his henchmen. The effect was that of the spoils system, with profits for the winner but not radically altering the community life.

But knowledge of the region was not exclusive property on the part of Cortés, and the rivalry for the quick riches that might lie in these native states was keen. Within a decade a rival of Cortés, the notorious Nuño de Guzmán, made his entry, looking for loot.

[2] The geomorphologic description is partly based on Thayer, Warren N., "The Physiography of Mexico," *Journal of Geology*, Vol. 24 (1916), pp. 61–94.

The passage of Nuño through the country produced a result very different from that of the men of Cortés. The Indian political and social order was shattered by looting, torture, and savage reprisals for fancied disobedience. In one year the Tarascan state was converted from one of prosperity and friendly submission to virtually a shambles, with chaotic but rebellious remnants.

This was the problem that faced the high tribunal, the Audiencia of Mexico, which delegated one of its members to "visit" and make recommendations for the rehabilitation of the territory. This official, Vasco de Quiroga, found himself so interested that he relinquished his post as a member of the Audiencia and took charge of the Bishopric of Michoacán.[3] A native people never had greater luck, for Don Vasco, in addition to his affection for them, had qualities of high value. He was a lawyer from a country of legalists, now a prelate of the church under a Catholic monarchy; he was a man of position in Spain with friends at court, a man of position also in the New World, whose knowledge of law gave him authority.

FIG. 4. Valley of Morelia.

Quiroga's first problem was that of the Indians, who had fled into the mountains at the time of the depredations of Nuño. He brought them back to urban living and re-established their settlements, with craft specialization by villages. The effect of his work is still apparent. The hills of Michoacán are Tarascan today, with important remnants of Indian culture, partly at least because of the wisdom and efforts of Vasco de Quiroga.

SETTLEMENT UNDER THE SPANIARDS

Tarascan towns everywhere had been more loosely knit than European towns of the same period, but organized towns they certainly were. For this reason the

[3] *Relación de las ceremonias y ritos . . . de la Provincia de Mechuacán.* . . . (Morelia, 1903), (hereafter cited as "Relación de Mechuacán"), pp. 90–94, 110–117 et seq.; Cortés, Hernán, *Cartas de relación de la conquista de Méjico*, Espasa Calpe, S.A. (Bilbao, 1932), II, 49; *Colección de documentos inéditos.* . . . (Madrid, 1877), Vol. 27, p. 155; *Tuspa* (*Tamatzula plus Zapotlán*), 1580, Feb. 20 (12–18–3), num. 16, VIII, 13 ff., cited in Jimenez I, CL, p. 2; Toussaint, Manuel, *Pátzcuaro* (México, 1942), p. 22, et seq.; *Colección de documentos para la historia de México*, publicada por Joaquín García Icazbalceta (México, 1859–66), Vol. II, pp. 248 et seq.; "Relación de la entrada de Nuño de Guzmán que dió Garsia del Pilar su interprete," Moreno, Juan Joseph, Vida de Don Vasco de Quiroga (Morelia, 1939), pp. 37–38; *ibid.*, p. 42.

Spaniards merely placed their civil and ecclesiastical authorities in previously settled towns and villages and for the most part were spared the necessity of establishing totally new settlements.

In some cases, however, new foundations had to be made. This was true in the case of the capital. Quiroga was not satisfied with the site of Tzintzuntzan, the Indian capital, which lay in a deep valley with its inhabitants scattered over the slopes. Also it lacked sufficient water for a large population. It had served adequately for an Indian settlement of somewhat dispersed dwellings, but certainly was unsatisfactory, said Quiroga, in its narrow valley and border-slopes, for a compact, orderly city of the kind that the Spaniards had in mind.[4]

On the other hand there was the site of Pátzcuaro, described in enthusiastic terms by Quiroga as having all of the necessary virtues. More than this, it had been a site of Tarascan settlement and, in spite of being several miles away, was regarded by the Indians as a suburb of their own capital.[5] Thus there was no resentment on the part of the Indians in the transfer. The complaint came only from Spaniards who had achieved a vested interest in the Tzintzuntzan site.[6] They were curtly overridden by Don Vasco.

At this same time, in Mexico City, the Viceroy was also thinking in terms of new settlements. He knew Michoacán at first hand and had crossed the open, well-watered valley of present Morelia.[7] This, to his mind, was the place for a capital city, not Pátzcuaro, the choice of Don Vasco. The foundations of Morelia were laid in May of 1541, three years after Quiroga established Pátzcuaro.[8] So started the rivalry between Pátzcuaro and Mendoza's city, which he named Valladolid but which is now called Morelia—a bitter rivalry that lasted for nearly half a century.

The difference between the two sites reflects the conflict between two cultures. The Bishop, Don Vasco, was concerned with an Indian region, its rehabilitation and well-being. For these ends Pátzcuaro was an obvious center of administration. It had been the choice of the Indians in an earlier period and had functioned as one of their capitals. It was the crossing-place of the most important native trade routes.

[4] Morelia, Mexico, *Museo Michoacano*, Anales . . . 3 v., 1888–91, Vol. 11, p. 40; León, Nicolás, *El Ylmo, Señor Don Vasco de Quiroga primer obispo de Michoacán* (Mexico), pp. 210–211.

[5] And it had been an official seat of tribal government not long before.

[6] *Ibid.*, pp. 177-78, 213, 241; *Documentos inéditos referentes al ilustrísimo Señor Don Vasco de Quiroga existentes en el Archivo General de Indias, recopilados por Nicolás León* (Mexico, 1940), p. 35.

[7] Winship, George P., "Coronado Expedition" (*Bureau of Ethnology, 1896; extract from 14th Annual Report*), p. 382, footnote. It is stated that Mendoza, the Viceroy, spent the New Year's season of 1540 in Patzcuaro, "the seat of the bishopric of Michoacan," p. 421.

[8] *Boletín de la Sociedad Michoacana de Geografía y Estadística* (Morelia, 1910), Vol. 6, pp. 265, 288 et seq.; Martínez de Lejarza, Juan José, *Análisis estadístico de la Provincia de Michuacán* (México, 1824), pp. 25 et seq.

It was in the midst of Indian settlements, all of which were associated with forested slopes such as those found around Pátzcuaro, where the simple digging stick was an effective tool in a subsistence economy. The Tarascans had never settled in great open valleys like that of Valladolid, where the heavy, resistant, compacted clays required plows and draft animals—both foreign to them. (Figs. 5 and 6.)

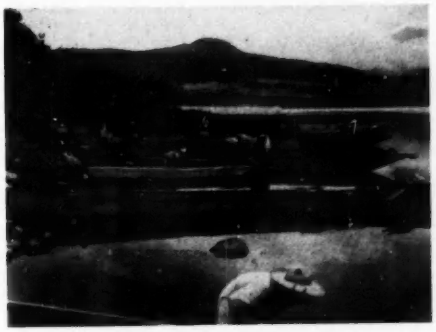

FIG. 5. Indian dugouts—Lake Pátzcuaro.

FIG. 6. Pátzcuaro—Market.

The Viceroy, on the other hand, was mostly concerned with Michoacán as a part of Mexico as a whole. He wanted advantages for the Spaniard and his techniques, not for the Indian. Valladolid had many square miles of flat, fertile land with an abundance of water. It was magnificent for pasturing animals, for plow cultivation, for the planting of European small grains, for irrigation and for surplus cash-crop production.[9] From this point of view the site of Valladolid was so clearly superior to that of Pátzcuaro that Quiroga's choice seemed quixotic and unreasonable. The Viceroy wrote to the King greatly disparaging Quiroga's judgments and abilities. (Fig. 7.)

[9] Basalenque, Diego. *Historia de la Provincia de San Nicolás de Tolentino de Michoacán, del Orden de N.P.S. Augustin* (Mexico, 1886), 1, 199; Moreno, *op. cit.*, p. 48.

FIG. 7. Street in Morelia.

Precisely as unreasonable, in fact, did Mendoza's choice, absurd in the light of Indian requirements, seem to Don Vasco. He stated in no uncertain terms that the site of Mendoza's choosing was worthless. The implication is strong that Don Vasco had no admiration for the judgment of the Viceroy. What interest had the Indian in pastures for strange animals, for fields suitable to the small grains of alien Europeans, or for techniques and practices unknown to him, such as plowing and irrigation?

These cultural attitudes of Quiroga and Mendoza not only were diametrically opposed to each other but represented different views as to the use of the area. One was derived from the Mediterranean; the other, although defended by a man from a Mediterranean culture, was based on an understanding of Tarascan Indians and their traditions of land use.

There followed a long period of altercation between the two groups associated respectively with Quiroga and Mendoza. Each thought the other to be either obtuse or dishonest. But in each case it was simply a matter of difference in the appraisal of the landscape in terms of disparate cultures.

Each party fought its case vigorously, with the Viceroy and his successors supporting the inhabitants of the city he had founded. Don Vasco was not one to yield without a struggle.[10] He defended the case of the Indians even before the Spanish King—going to Europe to do so. He was successful. Pátzcuaro remained the capital until after his death, when it lost out, not, however, to the European point of view which had been represented by the Viceroy. Mendoza had long since died but his cultural descendants had kept up the struggle, fighting a losing battle until geographical conditions leading to new developments in the Bajío to the north altered all of Mexican economy.

This northern valley land had been an unimportant area under the Tarascans and during the early years of the Spanish domination. There had been a slow filtering-in of a few Spaniards taking Indians with them to establish frontier settlements. It had

[10] *Documentos inéditos referentes al Illmo. Don Vasco de Quiroga. . . . op. cit.*, pp. 8 et seq.; Francisco del Paso y Troncoso, *Epistolario de Nueva España* (México, 1939), Vol. 5, p. 205; Icazbalceta, *op. cit.*, p. 244. In a report of Lebron y Quiñones of 1554 to the Viceroy Velasco he refers to the "City of Michoacán" and then to Pátzcuaro. Obviously the Viceroy accepted the designation for Valladolid (refer to *Archivo General de la Nación, Ramo Mercedes*, Vol. IV, p. 170).

been a slow process of expansion out of the Tarascan nucleus[11] until after the middle of the sixteenth century when the enormously rich mining strikes at Zacatecas and Guanajuato radically altered all of Spanish economy.

The formerly negligible northern and northeastern part of Michoacán quickly became a functioning part of the new economy stretching from Mexico City, the center of Spanish control, to the mines that became the keystone of Spanish prosperity. The importance of the Bajío in Michoacán lay in its capacity to raise surplus foods to supply the booming mining communities which were incapable of feeding themselves. This new importance brought about a complete change in the economic balance of the province.

PÁTZCUARO OFF-CENTER BY LATTER SIXTEENTH CENTURY

When Pátzcuaro was chosen by Quiroga as the capital it was ideally situated. It was central to the population and economy of the somewhat detached Indian province of Michoacán, and had the additional advantage of being on the route to the west.[12] With the developments of the latter half of the century Michoacán was transformed from a semi-isolated, self-sufficient province to a part of a great economic region extending from Mexico City to beyond Zacatecas. Pátzcuaro was not a part of this but was offside. It was separated from the increasingly important valleys to the north by rugged topography so that it served less well as a capital of Michoacán. Unfortunately the glowing hopes of the early years of the Conquest in riches to be gleaned from the west and northwest were crushed by the melancholy result of the Coronado expedition. So this route that might have placed Pátzcuaro in the main current of affairs dropped to insignificant importance.

With the declining fortunes of Pátzcuaro came the prosperity of Valladolid. It was not separated from the northern valleys by topography for it was actually in an extension of them.

The nagging problem of rivalry was now quickly settled. The cathedral—which meant central authority—was moved to Valladolid in 1579.[13] Thus Mendoza's city finally was the winner, not because of its immediate qualities as opposed to those of Pátzcuaro, but because of the development of the northern mines, far beyond the borders of the province.

As a final speculation, what would the result have been if the northern valleys had not become a part of Michoacán? Their inclusion in the political unit was largely

[11] Toussaint, *op. cit.*, p. 222; Relación que su Magistad manda se enbie a su Real consejo del Obispado de Mechuacán, 1582 March 4, leg. 374 (60–4–39), doc. of 15 ff., p. 16; Ponce, *op. cit.*, Vol. 1, pp. 535–536.

[12] Note that Mendoza, the Viceroy, passed through Pátzcuaro on his trip to Compostela for the official departure of the Coronado expedition. (See Winship, *op. cit.*, p. 377, p. 382 footnote 2.)

[13] Beaumont and Moreno give the date as 1580, but there seems to be no reason why the documents of the time should be doubted when they categorically state that the move was made in 1579.

a historical accident and perhaps a geographical monstrosity. If they had been included—as well they might—in a political unit made up entirely of Bajío valleylands, Michoacán would not have become a part of the mining axis. Pátzcuaro would have remained the demographic and economic center and the logical center of administration.

The rivalry of Pátzcuaro and Morelia was of the sixteenth century in Mexico. Vasco de Quiroga and Antonio de Mendoza were the men involved and it cannot be doubted that each, as a person, put his stamp on the country. But far more important was the problem of the clash of cultures, Mendoza representing one, Quiroga, the other. Neither represented merely a personal view. Each stood for the use of land according to the view of a great culture area—one, the Mediterranean, the other, Central Mexico. These views differed enormously from each other. Don Vasco re-established a pattern of life that was, in its fundamentals, largely Tarascan. It would have maintained Pátzcuaro as the important center of affairs had not the geography of precious metals and of level lands for broadcast sowing thwarted his intentions. Mendoza represented a European point of view and acted to fulfil the requirements of his office. He was the Spanish representative governing all of Mexico.

The fundamental problem was not unique to that time or country and the basis of rivalry pertains no more to an early period than to the present, for it was based on geographical factors and differing attitudes toward them.

RURAL DEPOPULATION IN SOUTHWESTERN ONTARIO

J. W. WATSON
McMaster University

THE GENERAL POPULATION SITUATION

MUCH is being said of the possibilities of immigration in Canada, both as a means of relieving the European situation and of improving that of Canada. However, the capacity of Canada to absorb new population has often been overestimated. As L. C. Marsh[1] has stated, "only a portion of the new immigrants who have come to Canada have remained within its borders." Emigration from the country is proceeding steadily. Indeed the present population might have been much the same, but for emigration, if it had been recruited from the natural increase.

It is not sufficiently realized that in many regions Canada is suffering from depopulation. This is particularly the case in the rural areas. As such, it is part of a general trend in the western world, where the productivity of agriculture has been immensely increased by modern technology without the need for a corresponding increase in rural population, and where, notwithstanding its expanding productivity, agriculture is relatively less important than heretofore. There is a smaller proportion of the gainfully-occupied population devoted to agriculture, as compared with industry and "service" activities.

The problem of rural depopulation is naturally considerable in a province like Ontario, where agriculture is developed on a highly commercial basis that dispenses with homesteading and part-time farming, and where the attraction of expanding cities competes for rural manpower. Therefore the extension of farm settlement by immigration might be ill-advised. It is true, as Professor Hurd has shown,[2] that "if one adds to the unused lands available in Northern Ontario say half the idle or abandoned land in Southern Ontario . . . the province has arable lands considerably in excess of the prospective demand of her own population." Nevertheless, he goes on to point out, the settler in Northern Ontario has to face competition in the goods he is best able to produce from the low-cost, surplus-producing Prairie Provinces. As for Southern Ontario, the increasing application of scientific methods and machines to agriculture has increased production, even though, during the war, agricultural manpower was reduced. This has prompted Colonel Kennedy, the provincial Minister of Agriculture, to declare that what Ontario needs is fewer farmers and better farms.

[1] Canada, Dominion Advisory Committee on Reconstruction, *Report on Agricultural Settlement Possibilities in Canada*, by W. Burton Hurd, Hamilton, 1944; see introductory note by L. C. Marsh.

[2] Hurd, W. B., *ibid.*, Summary and Conclusions, p. 7.

TRENDS OF DEPOPULATION IN ONTARIO

And fewer farmers there are. Rural depopulation is widespread. (See Figures 1 and 2.) The only townships showing an increase in the last census were suburban ones, or those in the dairying districts and fruit and tobacco belts. Elsewhere in general farming districts depopulation has been prolonged. It started as early as 1851 in townships once or twice removed from the cities, such as Toronto, Hamilton, and Brantford, where farm production had not been stimulated by the urban market (as in the suburban townships), yet rural industries were declining under the impact of city ones.

Between 1861 and 1881, depopulation had spread to the vicinity of London and Windsor, and into townships traversed by radiating roads and railways. Once more, rural institutions gave way to expanding city ones, without any compensating in-

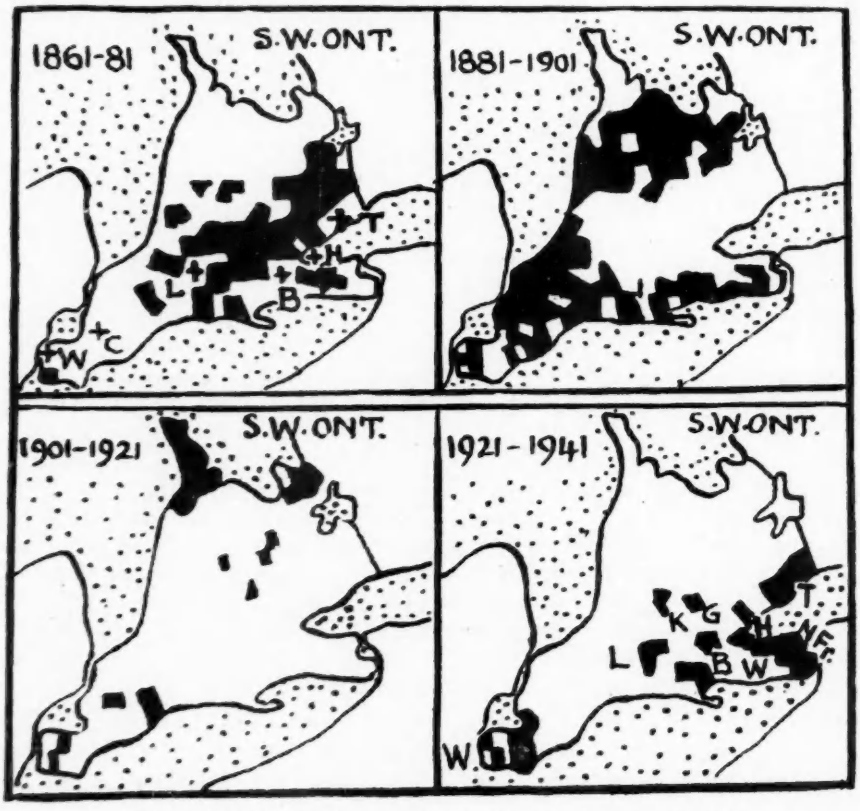

FIG. 1. Periods of maximum rural population, Southwestern Ontario.

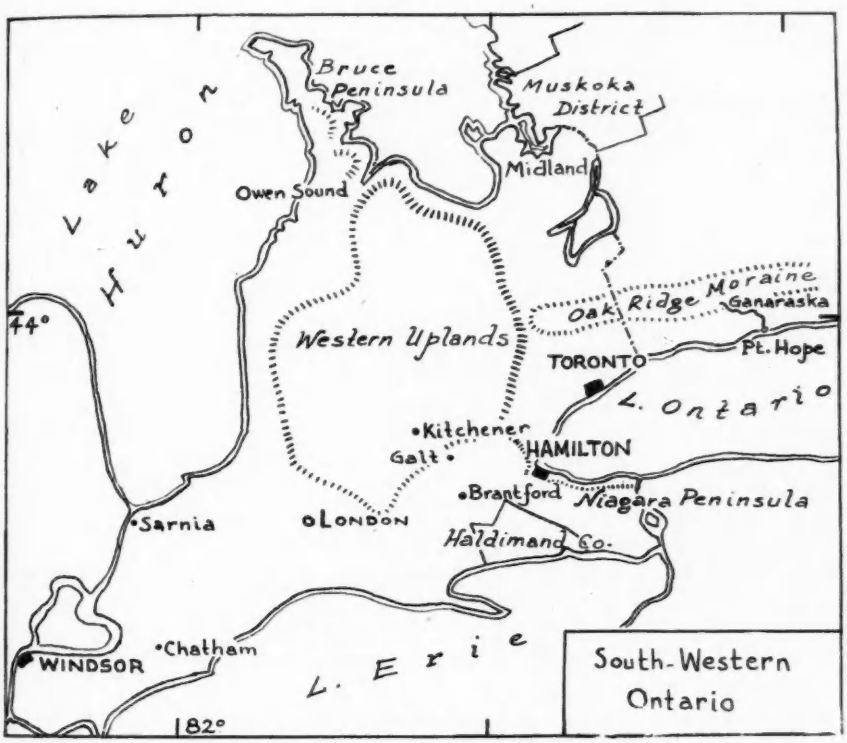

FIG. 2. Identification map of Southwestern Ontario.

crease in farm employment. Immigration was meantime pushing into the townships of the Huron lakeshore and the Western Uplands. Yet after the pioneer phase, when many homesteads were cut out of the forest and rural industries begun, the townships started to empty; that is, between 1881 and 1901. Homesteads were abandoned or amalgamated and rural plants closed down. Soon after 1901 depopulation spread through Bruce Peninsula and the Muskoka District. Indeed the rural population of the whole Province reached its maximum between 1891 and 1901, since when there has been a decrease of 28 per cent.

CAUSES OF RURAL DEPOPULATION

It has been claimed that rural depopulation resulted either from the abandonment of sub-marginal farm land—taken up too hurriedly in the pioneer advance—or from the physical deterioration of the environment through deforestation, soil erosion,

and so forth.[3] Closer examination will show that such conclusions cannot be generally applied. They may be true of a few particular cases, but, in general, rural depopulation occurred before the maximum amount of land was occupied; it was not due to the abandonment of submarginal land. Moreover, since it began before the maximum acreage of land was cleared, it cannot be attributed to deforestation and the attendant ills of flooding and soil erosion.

MIGRATION OF THE NON-FARM POPULATION

Depopulation started with the migration of the non-farm population from townships where village functions could no longer compete with the spread of the city idea and with the extension of city services. A social rather than a geographical factor was involved—although, of course, the spread of city notions of life was conditioned by roads, railways, and commercial connections. To look at a map of early depopulation and compare it with a soil map of the Province (see Figure 3) is to notice that the regions which first declined were not necessarily those that suffered from poor drainage or infertile soil. On the contrary, they straddled good soils as well as poor ones, well-drained sites in addition to ill-drained ones. Rather the regions which first declined were those that first felt the impact of city institutions, without being able to offer any compensating advantages (such as the lucrative consumer markets gained by the suburban townships). They were those, in fact, which suffered from a village set-up that was unable to bear the competition of more attractive urban standards.

That depopulation was due to social and economic changes (conditioned no doubt by geography) rather than to physical deterioration is shown by the fact that these townships, though losing non-farm population, still invited farming immigrants. In other words, farm population increased, while rural population as a whole decreased.

[3] Ashley, C. A. (ed.), *Reconstruction in Canada*, Toronto, 1943. See article "Soil and Water," by A. F. Coventry. "There are records of land cleared of trees, cultivated, and abandoned as no longer useful within the span of eighty years." This is true, but abandonment for social or economic reasons occurred with greater frequency, before the land was cleared.

Coventry, A. F., "Desiccation in Southern Ontario," *Trans. Royal Soc. of Canada*, 1940.

Mayall, K. M., *The Natural Resources of King Township*, Toronto, 1938. Mayall also implies that soil erosion is a prime cause of rural depopulation. "Erosion has removed the topsoil [and] farms have been abandoned."

Ontario Dept. of Planning and Development, *Report on River Valley Development in Southern Ontario*, Toronto, 1945, p. 22. Here again depopulation is attributed to soil erosion. But though such erosion has undoubtedly exaggerated depopulation, the drift of people from village and farm had begun before erosion was a serious problem.

Ontario Dept. of Planning and Development, *Report on Conservation in Eastern Ontario*, Toronto, 1946, p. 17. Erosion is said to precede farm abandonment. However, on page 19 it is suggested that when mills were allowed to fall into disuse and mill dams were destroyed, then the watercourses became dry.

In fact, as Mr. Plewman shows,[4] immigration during the decades 1851 to 1881 was greater to the farms than to the cities, yet rural population declined from about 86 per cent of the total population to 75 per cent. This was due in a considerable degree to the drift of the non-farm population to the cities[5]—a drift that has continued ever since. To take but a few examples, there has been a decline, down to 1941, of 66.2 per cent in the number of blacksmiths, 79.9 per cent of millers, and 94.5 per cent of carriage builders.

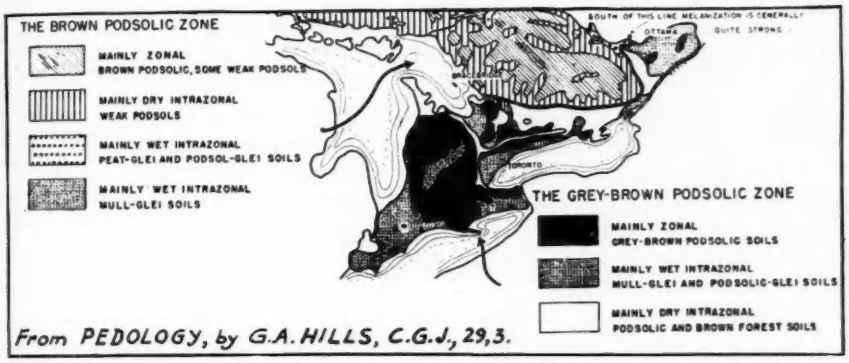

FIG. 3. Soil types of Southwestern Ontario, from G. A. Hills.

HALDIMAND—AN AREA OF POOR DRAINAGE

Haldimand County forms a good illustration of the trend.[6] It lies in a region of poor natural drainage and its soils are very deficient in lime. Therefore one might suppose that its early decline in population, which set in about 1861, was due to the early recognition of its comparative infertility. Yet the maximum number of farms was not reached until 1891, thirty years after the decline. Depopulation cannot have been due to farm abandonment. Moreover, the maximum acreage of cleared and improved land was not reached until 1911. Depopulation was not the result of soil wastage. As a matter of fact, farming continued to improve right up until the

[4] Plewman, G. W., "Rural Depopulation in Western Ontario," B.A. Thesis, 1934, McMaster University, Hamilton, p. 18 ff.

[5] There was also a drift of farm population into the United States which we may attribute, not to the rapid exhaustion of the Canadian soils, nor even to the dwindling of available land, but to the greater prosperity of the greater country. Natural increase and immigration together were not sufficient to offset the loss by emigration, by migration to the cities, and by the incorporation of rural areas as "urban" ones.

[6] Watson, J. W., "Mapping a Hundred Years of Change in the Niagara Peninsula," *Canadian Geographical Journal*, Ottawa, Vol. 32, No. 6 (June 1946), p. 273 ff.

depression of the thirties, and the number of workers per farm did not reach a maximum until 1931. In this case, then, rural depopulation over eight decades has gone along with an improvement in farming.

MIGRATION OF THE FARM POPULATION

However, it is true that in most counties, a drift of the farm population itself occurred. It seems to have begun between 1881 and 1891. Rural Ontario then lost 188,000 people. About two thirds of these were farmers and their families who left Ontario to seek better agricultural prospects in Western Canada or the Midwestern States. The number of Ontario-born residents in the Canadian West increased by 50,648 in this decade.[7]

This shift of the farm population itself was due to a decline in the relative importance of farming and to changes in the type of farming in Ontario. In becoming more urbanized, the Province offered less social and economic support for its villages and its farms. From sample studies in the Niagara Peninsula it seems clear that first, the villages declined, then farms were abandoned. Up to 1883, agriculture was more important than any other occupation in Ontario. Then the depression of 1883 to 1896 struck. During this time the West was opened up, and afterwards Ontario was unable to compete as favorably for world markets as could the Prairies, especially in grains. In particular, the growing of Spring wheat was virtually abandoned. (Even before the depression threw into bold relief the contrasts between Ontario and the West, Prof. Buckland,[8] alluding to the probable competition arising from the vast production of grain crops in the Prairies, advised that "it would be wise for the Ontario farmer to cultivate less land for grain, and to use the remainder for the purpose of pasturing cattle and sheep.") American competition was also crucial. The McKinley tariff of 1890 led to a fall in the barley acreage in Ontario of 202,101 acres in the next two years. The acreage of wheat dropped off by over 600,000 acres.

CHANGES IN FARMING

Thus, whereas agriculture employed 52 per cent of the gainfully occupied males of Ontario in 1891, in 1941 it employed only 31.6 per cent.[9] To meet this falling-away in the importance of agriculture there has been an improvement in methods of

[7] This situation drew the remark in 1891 of Goldwin Smith that "if the Americans do not annex Canada, they are annexing the Canadians," quoted in Jackson, G. E., "The Emigration of Canadians to the United States of America," *Annals American Academy*, Vol. 107, No. 196, p. 25.

[8] Ontario Agricultural Commission, Report of the Commissioners, Toronto, 1881, Vol. 1, p. 344.

[9] In correspondence with A. H. Le Neveu, Chief, Social Analysis Branch, Dominion Bureau of Statistics, Ottawa.

farming. As Prof. Hurd[10] has shown, subsistence and small general farms are on the decline. Part-time farms, except in suburban townships—where it is possible to raise vegetables and berries in the summer, and work in a factory during winter—are much more limited. Crops grown for sale have been replaced by crops grown for feed, and sold as milk, bacon and eggs. Accordingly, the size of the farm unit increased. There was the frequent absorption of the small farm in the larger one, without the maintenance of the original farm population, but on the contrary with its decline. Heavier capitalization generally demanded a larger acreage basis, and modern commercialized farms, run on the lines of a combine, have begun to appear. The average size of farm grew from 96 acres in 1881 and reached a maximum of 119 in 1931, in spite of the fact that during this time there was a great increase in the number of small fruit and tobacco farms.[11] The expansion of the farms without a corresponding increase in farm employment lowered the density of farm population.

These changes in method of farming, requiring as they did more specialization and greater capital outlay, were successful only in the more accessible or the more fertile areas. Townships situated in areas of wet intra-zonal soils and of loose, dry, sandy soils found it difficult to meet the situation, and, as a result of the greatly increased economic risk, submarginal lands became abandoned. Even where farmers might have continued on a more or less subsistence basis, the conflict between the desire to live up to the social standards of the economically favored areas, and inability to do so, led to the desertion of their farms in search of better things.

THE GANARASKA—A BADLY ERODED AREA

Again, flooding and erosion have often been blamed for this abandonment; yet, in reality, they follow it rather than precede it. This is implicit in the report on erosion in the Ganaraska watershed.[12] The region lies across a belt of dry, intrazonal morainic soil which is easily eroded and is not very fertile even under the best of conditions. On all hands there are signs of severe erosion. Springs have dried up, river beds are dry, and the water table has fallen. Gullying is advanced and winds have stripped the exposed soil and blown it into sand dunes, often burying good fields. It was not unnatural to assume that this resulted from deforestation and was the cause of depopulation. But the population in the watershed townships began to fall by 1861, long before the cutting of timber on the upper watershed slopes reached its maximum, in 1883. Yet it was only after this that erosion began.

[10] Hurd, W. B., *Contemporary Demographic Movements Underlying Canadian Agricultural Development*, Hamilton, 1943, pp. 29, 72. Cf. also: "Population Movements in Canada, 1921–1931, and Their Implications," *Proc. Can. Pol. Science Assn.*, May, 1934; "Some Implications of Prospective Population Changes in Canada," *Can. Jour. Econ. and Pol. Science*, November, 1939; and Haythorne, G. V. and Marsh, L. C., *Land and Labour*, Toronto, 1941.

[11] McArthur, I. S., and Coke, J., "Types of Farming in Canada," Ottawa, 1939 (*Dom. of Can., Dept. of Agric., Pub. 653*), p. 18.

[12] Richardson, A. H., *The Ganaraska Watershed*, Toronto, 1944.

Actually, in this case the movement from the townships started with economic depression, and was in full swing before the effects of erosion were noticeable. It might very well be claimed that erosion is the serious problem it is today because of the deteriorating social and economic conditions that led to the abandonment of farms, or to poor methods of farming. The Ganaraska report points the contrast between areas of poor general farming, where erosion is prevalent, and better farms in the neighborhood. Families still following a homesteading standard in 1941 spent an average of 150 dollars per person per year, whereas those who attempted better farm methods spent over 180 dollars. Only 10 per cent of the former had electricity in their homes, as compared with 30 per cent of the latter. Forty per cent of the former owned automobiles, whereas 61 per cent of the latter did. It would be interesting to know to what extent these low living standards and poor methods caused soil erosion and population decline, and to what extent they were their concomitants. Meanwhile, as MacLean indicates,[13] the decrease in the farm population has now stabilized itself, in most townships, at about 82 per cent of the maximum. This would suggest that the present population is the optimum one for existing social conditions.

EFFECTS OF DEPOPULATION ON FORMS OF SETTLEMENT

The loss of both non-farm and of farm population has affected the forms of settlement in rural Ontario.[14] The geography of rural institutions is very different today from what it was in the eighties. Sawmills and flour mills have disappeared along with saddleries, smithies, cooperages, carpenter shops, and so on. The use of the automobile has made it possible and preferable to travel a considerable distance to one good mill rather than to put up with inferior products from inadequate, local plants. The local concerns have been closed—not, as is so often presumed, because the streams ran dry, but because they were replaced by larger and more centrally located mills. The part-time, small-hold farmers, that used to group themselves around these institutions, have also gone.

Thus many small institutional centers have given way to a few larger, nodal settlements. The rural pattern, outside of the towns and the larger villages, is therefore more open than ever. This situation has probably had the social effect of driving still more people, who are not actually occupying a farmstead, into the nucleated settlements away from the open-country districts—and it must be counted yet another factor in rural depopulation.

It is obvious, then, that while depopulation may have gone along with a better

[13] MacLean, M. C., "The Correlations between Population Density and Population Increase in Canada," *Proc. Can. Pol. Sci. Assn.*, 1933, p. 213. Cf. "Factors in the Growth of Rural Population in Eastern Canada," by Messrs. Lemieux, Cudmore, MacLean, Pelletier and Tracey, *Proc. Can. Pol. Sci. Assn.*, 1934.

[14] Linsay, C. E., "A Study of Rural Migration in a Typical Ontario Township," B.A.Sc. Thesis, 1914, Ontario Agricultural College, Guelph.

and more economical use of the land, it has been followed by a general deterioration in institutional life. This is particularly the case with cultural institutions. Commercial ones have reacted much more quickly to the situation and, by means of economic consolidation and geographical concentration, have moved to the towns, and from these as centers have offered an improved service to the country.

EVIDENCES OF CULTURAL LAG

Churches and schools, lodges and clubs have not been so quick to recognize the displacement of the hamlet. Here the forces of cultural lag have worked to prevent these institutions, for sentimental reasons, from readjusting themselves by means of consolidation or confederation. There are still many one-room schools, last remnants of outmoded hamlets, where the work of eight grades is entrusted to a single, poorly qualified teacher. Many small churches preserve inefficient programs rather than consolidating their work.[15]

In Caistor Township, for example, the population has declined steadily since 1871, and is now only 52 per cent of the maximum. In spite of this, the number of churches increased until between 1901 and 1911 it stood at 142 per cent. At the same time membership had fallen by approximately a third. Thus the township appeared to be greatly over-churched. Several churches were closed between 1911 and 1934, but during the depression new evangelical sects were established, so that the number of religious communities is still 115 per cent of the 1871 total.

The early drop in township population did not lead to a corresponding decrease in the number of churches, because the farm population still increased and new churches were built to meet its needs. Since locomotion was limited, the radius served by each church was small and its services were in good demand. But after 1911, when automobiles began to appear, many population centers were overchurched. Some change occurred in the union of Methodists and Presbyterians; nevertheless, with the invasion of new sects during the depression years, competition between religious groups increased and arrested the movement toward consolidation.

However, as Rockwell Smith shows,[16] where the denominational population falls below 13 per square mile there can be no financial basis for a church, and its members are faced with either extinction or consolidation. Consequently the tendency for institutional consolidation, at geographical nodes, is growing among both the churches and the schools. The new mergers of several small school districts into a few large ones, the building of consolidated schools, the establishment of larger parishes and efforts at church comity—these and other developments are all answering to the same controls of social geography as the changing distribution of banks and stores, workshops and mills.

[15] Felton, R. A., *Local Church Co-operation in Rural Communities*, New York, 1940. Cf. Wragg, G., "Library Service in Ontario and Some Possible Improvements, Especially in Rural Library Service," B.A.Sc. Thesis, 1943, Ontario Agricultural College, Guelph.

[16] Smith, R. C., *The Church in Our Town*, New York, 1945.

Thus the end-product of depopulation in rural Ontario may well be better churches, better schools, and better farms. If this were substantiated, it would obviously be unsound to press for large-scale immigration, as is being done, whether it were physically feasible or not. Social geography would not permit it, even if physical geography did.

DELIMITATION OF THE GEOGRAPHIC REGIONS OF CHINA

SHU-TAN LEE

National Central University, Nanking, and University of Maryland

A NECESSARY procedure in the study of regional geography is the division of land into concrete unitary regions for the purposes of separate study and areal comparison. Yet in the active work of dividing regions, great difficulty is encountered in delimiting them and setting proper and satisfactory boundaries. Because the physical element complexes used as criteria for demarcation are often non-correspondent and indecisive, and because the regional divisions of each physical element such as topography, climate, and soil are not always clearly defined, many geographers, however competent, have failed to carry out an adequate delimitation of synthetic geographic regions for many parts of the earth surface. No two geographers have ever fully agreed on any system of regional delimitation. Usually geographers are differently trained, have divergent views, and make various approaches. The latter is especially true in the case of China where the area is large and the physical elements are complicated and less well known. Attempts have been made by several geographers to define the geographic regions of China; outstanding examples are those of George B. Cressey and Chi-Yun Chang. Their systems, however, depart widely from each other, and the regions thus divided are far from coincident and corresponding. A distinct and objective system of delimitation is evidently needed for the world in general and for China in particular.

METHOD EMPLOYED

Otto Maull has advocated a simple yet objective method of regional delimitation.[1] This is, to select several basic physical elements like topography, climate, soil, and vegetation as criteria, then draw the border lines of criteria regions, set-by-set, on a single map. The overlapping border lines thus drawn will be seen roughly to correspond to each other and to form line-bundles which are termed *boundary girdles*. Delimitation of synthetic geographic regions is thus made easy by following the guidance of these boundary girdles which are taken, in order of their size, as major and minor lines of division.

[1] Otto Maull: "Staatsstrukur und Staatsgrenzen," *Kartographie und Schulgeographie Zeitschrift*, Vol. 8 (1919), pp. 129–36; and *Politische Geographie*, pp. 601–08, 1925, Berlin.

This contribution to geographic method and to the geography of China is published under the sponsorship of O. E. Baker of the University of Maryland.

I find it both possible and feasible to apply Maull's method to the case of China. The physical elements selected as criteria are seven: topography, drainage, climate, soil, vegetation, land use, and agriculture. Each of these has been divided into regions by authoritative geographers. J. S. Lee studied natural provinces and divided China into 19 regions, largely topographical (Fig. 1), which can be considered as a framework of physical division.[2] Some of his regions are, however, not marked by definite lines. The reason for this neglect is not quite clear. A study of drainage regions was made by F. Hung sometime earlier (Fig. 2).[3] Hung tried to use drainage basins as a preliminary division of geographic regions of China. For

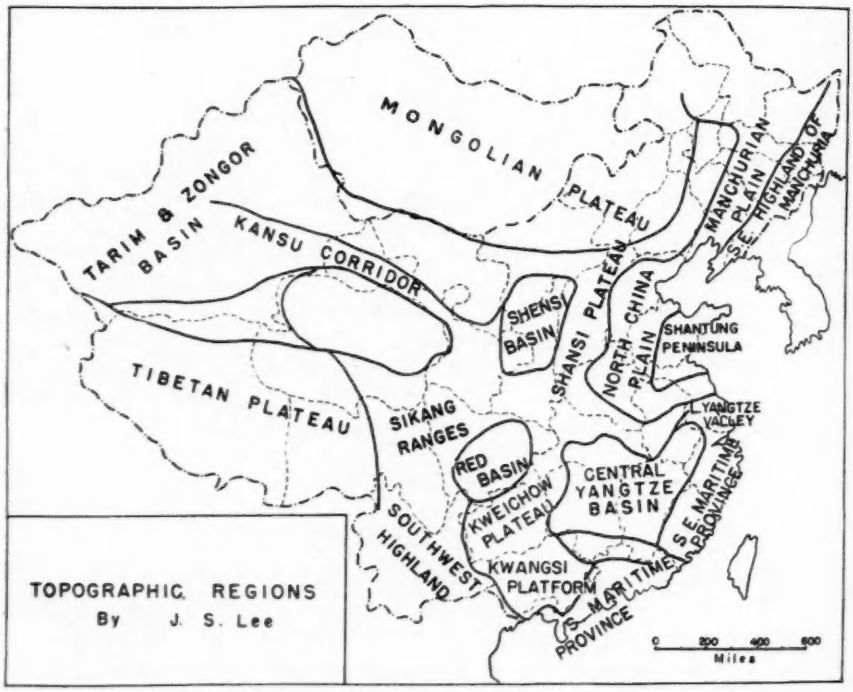

FIG. 1. Topographic regions of China, according to J. S. Lee, in *Outline of Geology of China*. Some of Lee's regions, as shown, are not marked by definite boundaries.

[2] J. S. Lee: *Outline of Geology of China*, Chapter I, 1939, Cambridge University Press, England.

[3] F. Hung: "A Preliminary Study of Demarcation of Geographic Regions of China," *Journ. Geog. Soc. of China*, Vol. I, No. 2 (March 1934).

climate, Coching Chu's classification still stands unchallenged in spite of recent classifications made by following both Köppen's and Thornthwaite's systems. Both these proved to be unsatisfactory for the observed conditions in China. Thornthwaite's new system of climatic classification might show better results, but so far it has not yet been worked out for regional application. Later in 1936, Chang-Wang Tu, with increased volume of climatic data, made a revision of Chu's classification.[4] Tu's provinces are depicted in Figure 3.

The map of soil regions of China was first drawn by James Thorp in 1934 and has been revised now and then to include new informations obtained from recent surveys.[5] The present map (Fig. 4) is a simplification of the 1943 revision. Based

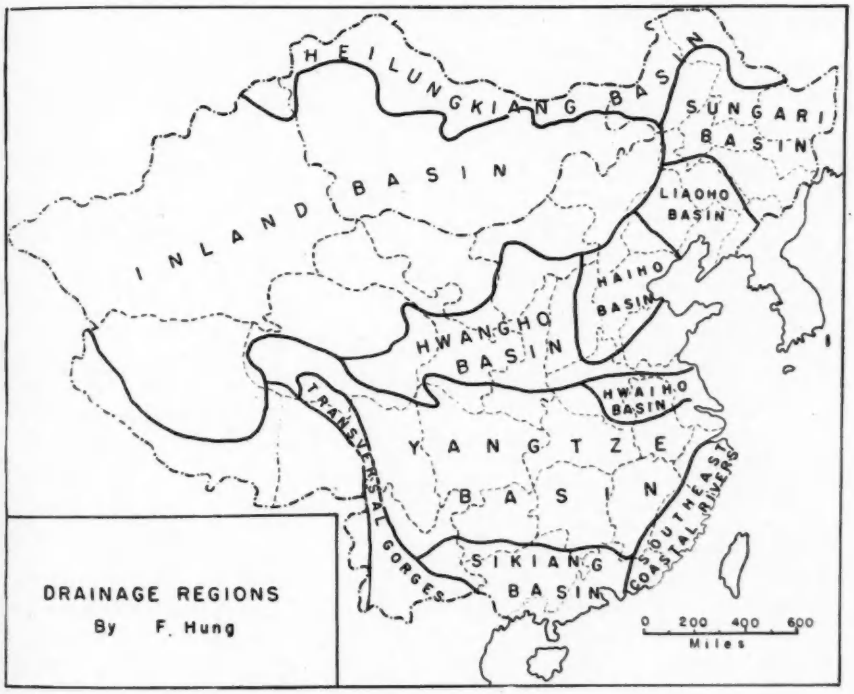

FIG. 2. Regions of China according to drainage basins, by F. Hung.

[4] Coching Chu: "Climatic Provinces of China," *Memoir I*, National Research Institute of Meteorology, Academia Sinica, 1930; Chang-Wang Tu: "Climatic Provinces of China," *Journ. Geog. Soc. of China*, Vol. 3, No. 3 (September 1936).

[5] James Thorp: "Geography of the Soils of China," *National Geological Survey*, Nanking, 1936.

largely on Thorp's work, P. V. Huang[6] attempted a division of natural vegetation of China in 1941 (Fig. 5).

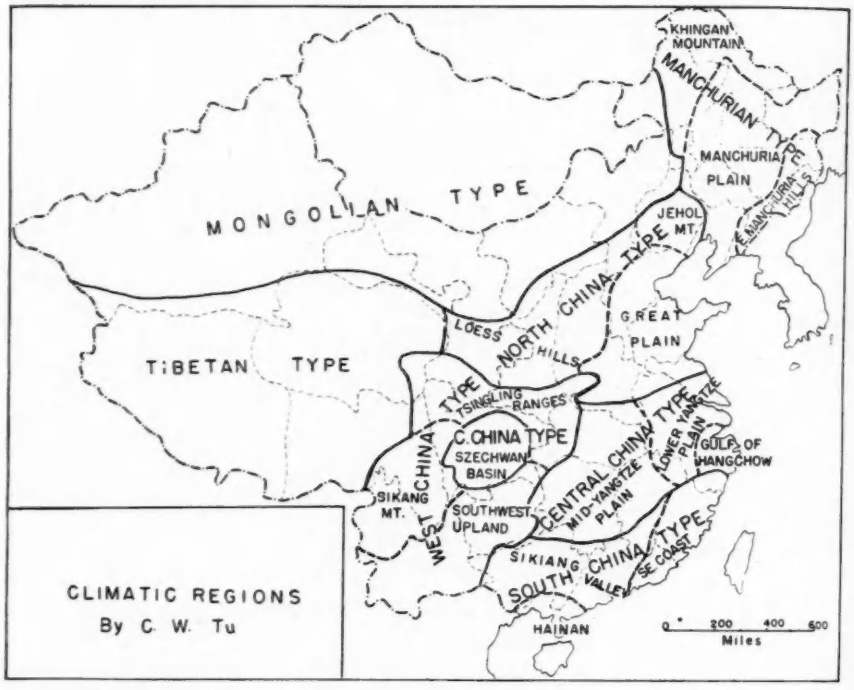

FIG. 3. Climatic regions and sub-types of the climate of China, according to C. W. Tu.

For land use and agricultural regions, both J. L. Buck's and Huan-Yuan Hu's classifications are used[7] (Figs. 6 and 7).

Combining the above regions, and outlining their boundaries overlappingly on one map, we find that these lines run fairly closely together, and the *boundary girdles* thus formed can be readily discerned.

[6] P. V. Huang: "The Vegetation Regions of China," *Journal of History and Geography*, Vol. I (1941), No. 4, National Chekiang University.

[7] J. L. Buck: *Land Utilization in China*, University of Chicago Press, 1937; Huan-Yuan Hu: "Agricultural Regions of China," *Journ. Geog. Soc. of China*, Vol. 3, No. I (March 1936).

MAJOR BOUNDARY GIRDLES

As shown in Figure 8, the superimposed boundary lines form braided girdles to be used as guides for tracing the limits of geographic regions. Boundary girdles are seen to be located where the distinct contrasts of regional characteristics take place. Wherever four or more of the seven sets of lines are braided together, a major geographic divide is obtained. Some of the more pronounced girdles or line-belts are noted as follows:

The Khingan-Taihang girdle On the west margin of the North China plain and the Manchurian plain, the Khingan-Taihang range rises abruptly and forms a steep wall acting as a climatic barrier which prevents further marked penetration of the monsoon influence inland. It serves also as the eastern boundary of loess deposits. The line distinctly marks the contrasts between the loess plateau and steppe land to the west and the alluvial plains and farmlands to the east.

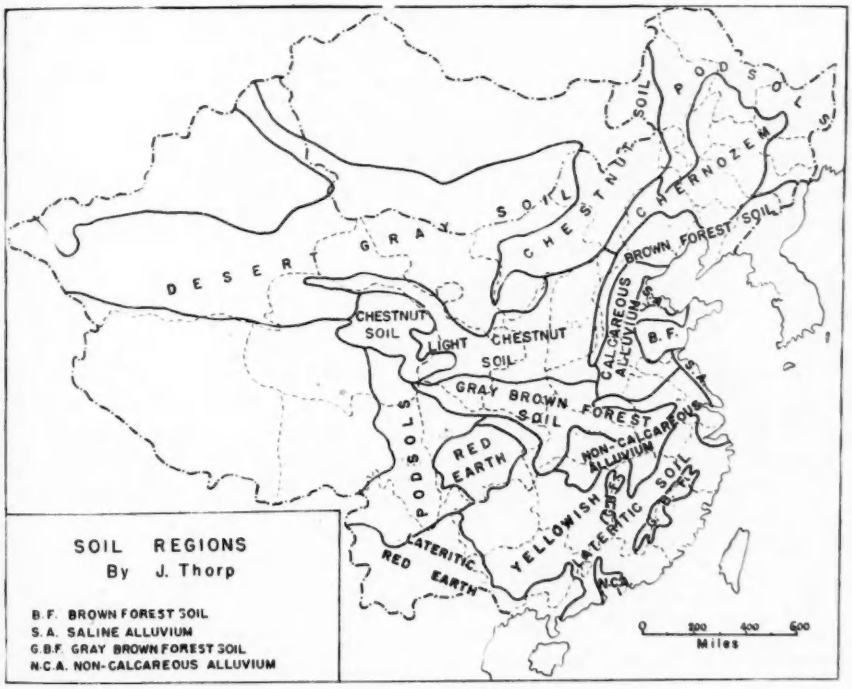

FIG. 4. Soil regions of China, adapted from James Thorp. The soils are here grouped into thirteen types.

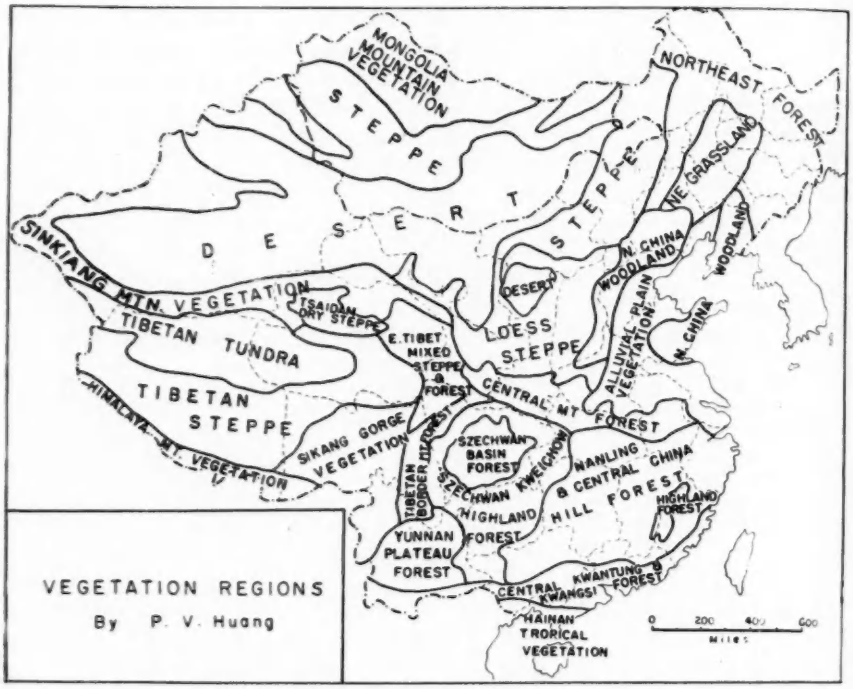

FIG. 5. Regions of vegetation, according to P. V. Huang.

The Inshan-Great Wall line The Mongolian desert extends as far south as the Inshan range, which is supplemented by the artificial Great Wall built in the early years to defend the Chinese farmers from nomadic invasions. No agriculture of any significant scale is possible north of this line, which, therefore, sets a limit to sedentary culture. It is a line of both geographical and historical importance.

The Kunlun and Tibetan Border The lofty and snow-clad plateau of Tibet with an elevation of 10,000 feet and above is bounded on the north by the Kunlun Mountain and on the east by the Tibetan Border Ranges running through western Szechwan and Yunnan provinces. Rugged, barren, and frozen for the most part of the year, it is a land of little use and shut out from the outside world.

The Tsingling and Hwai-ho line In the study of the geography of China, one never fails to notice the sharp contrast in landscape between North and South China. The North is a land of yellowish-brown earth, subhumid to semiarid, with limited, uncertain rainfall and unleached calcareous soils. The South has more abundant and reliable rainfall, is humid with leached, generally non-calcareous soils and a green

landscape at all seasons. Kaoliang, millet, wheat, and beans constitute the chief crops in the north, while in the south rice is the dominant crop. The line begins at the foot of the Tibetan Border in southern Kansu, runs eastward with the Tsingling range to as far as northern Anhwei where it follows the Hwai River to the coast.[8] It is commonly regarded as the most prominent boundary, a dividing line of almost all geographic elements.

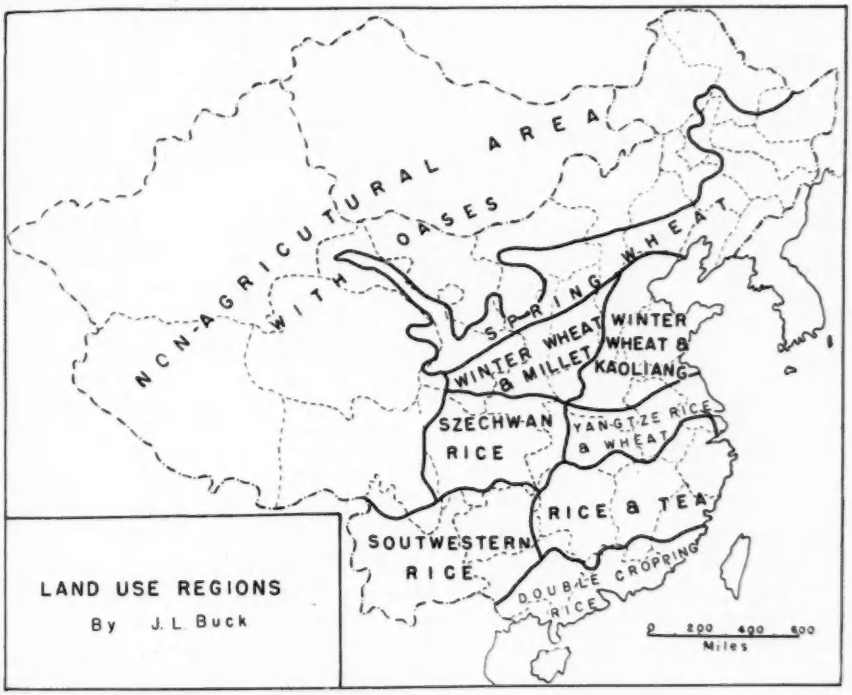

FIG. 6. Nine land use regions of China, after J. Lossing Buck.

The Red Basin Border The fertile and soft red sand-stone basin of Szechwan is encircled by high barrier ranges on all sides. Being so secluded, the region possesses distinct features widely different from the neighboring areas.

The Yunnan and Kweichow Plateau Rim This dissected plateau of 5,000 feet elevation and above forms a region of its own. Its eastern rim can be traced as the southern continuation of the Khingan-Taihang range and marks the boundary between southwestern China and southeastern China.

[8] Shu-Tan Lee: "Observations on Geographical Landscapes Along the Peilungkiang, South Kansu," *Journ. Geog. Soc. of China*, Vol. 8 (1941).

The North Bank of Yangtze River While many may doubt the existence of a major regional boundary along the Yangtze River, significant changes of physical phenomena do take place on its north bank, where marked boundaries of topography, soil, vegetation, and land use run almost on the same track.

The Nanling girdle Acting as a divide of the Sikiang and the Yangtze, the Nanling range is the distinct boundary between the temperate Central China and the subtropical South China. The broad parallel ridges of Nanling do not, however, provide a sharp limit. The line has to be drawn along its southern side.

The Kiangsi-Fukien Border The southeast coastal area of China with its indented shorelines and rapid, short streams running separately into the sea forms another region of marked characteristics. Its land boundary is clearly set from south of the Tsientang River along the Kiangsi-Fukien border to northeastern Kwantung.

GEOGRAPHIC REGIONS

By marking out the principal boundary girdles, we are able to divide China into twelve well-defined major geographic regions. To show their synthetic character,

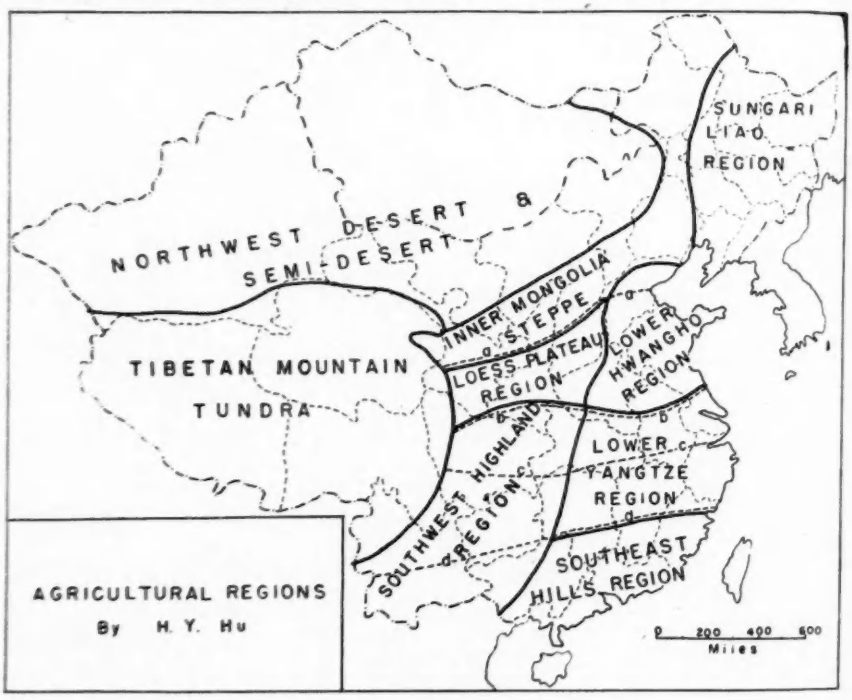

FIG. 7. Outlines of the agricultural regions of China by Huan-Yuan Hu.

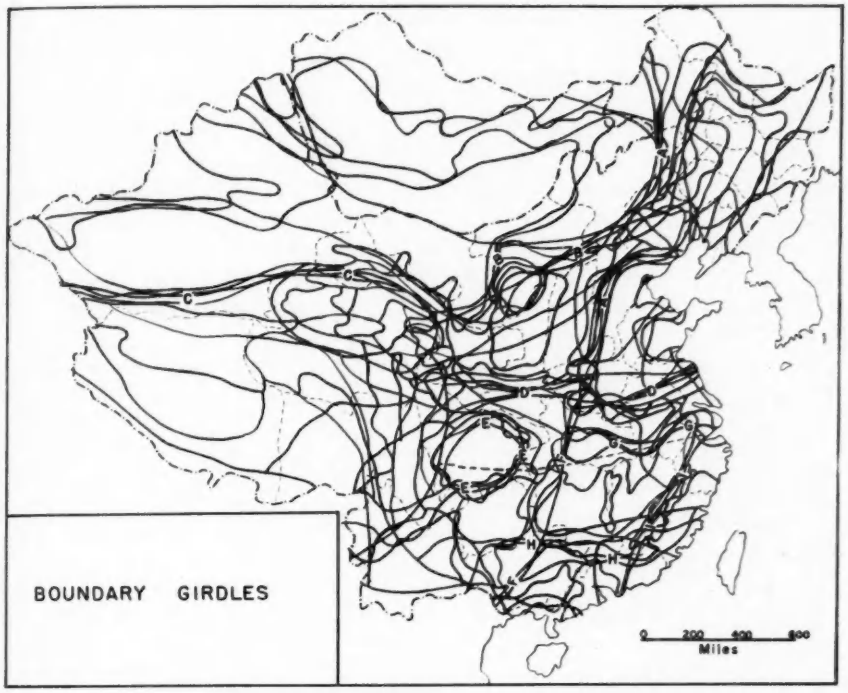

FIG. 8. The composite boundary girdles of China derived by superimposing the regional boundaries of topography, drainage, climate, soil, vegetation, land use, and agriculture on one map. The principal boundary girdles are identified by letters: A—Khingan-Taihang girdle; B—Inshan Great Wall line; C—Kunlun and Tibetan girdle; D—Tsingling and Hwai-ho line; E—Red Basin border; F—Yunnan and Kweichow Plateau Rim; G—north bank of Yangtze river; H—Nanling girdle; I—Kiangsi-Fukien border.

special terms like plain, plateau, steppe, humid, tundra, forest, loess, and double-cropping, indicating particular phenomena, are purposely avoided in the regional nomenclature.

A brief description of the characteristics of each region follows. (See Figure 9.)

THE NORTHEAST REGION

Located north of the Great Wall and east of the Khingan Mountains, surrounded by forested ranges 1,500 to 6,000 feet high, drained in the center by the Liao-Sungari rivers, this is a land of black, fertile soil. Climatically, it has long and severe winters and hot but short summers, with annual rainfall of 15 to 30 inches. Chief crops

are soybean, kaoliang, millet, and spring wheat. About 12 per cent of the total land is under cultivation.[9] The region has large resources of coal and iron and a great potential industrial development.

SINKIANG AND MONGOLIA REGION

Located west of Khingan and north of the Kunlun-Nanshan and Inshan ranges, this region covers a vast area of desert and semi-desert of chestnut-brown soil with great temperature ranges, and scanty and unreliable rainfall amounting to no more than 10 inches a year. It is largely a low plateau of about 3,000 feet elevation with forested mountains on its northwestern margin and several depressed inland basins in the center. Less than 1 per cent of the land is oasis, and therefore cultivable, while a considerable part is used for pasture.

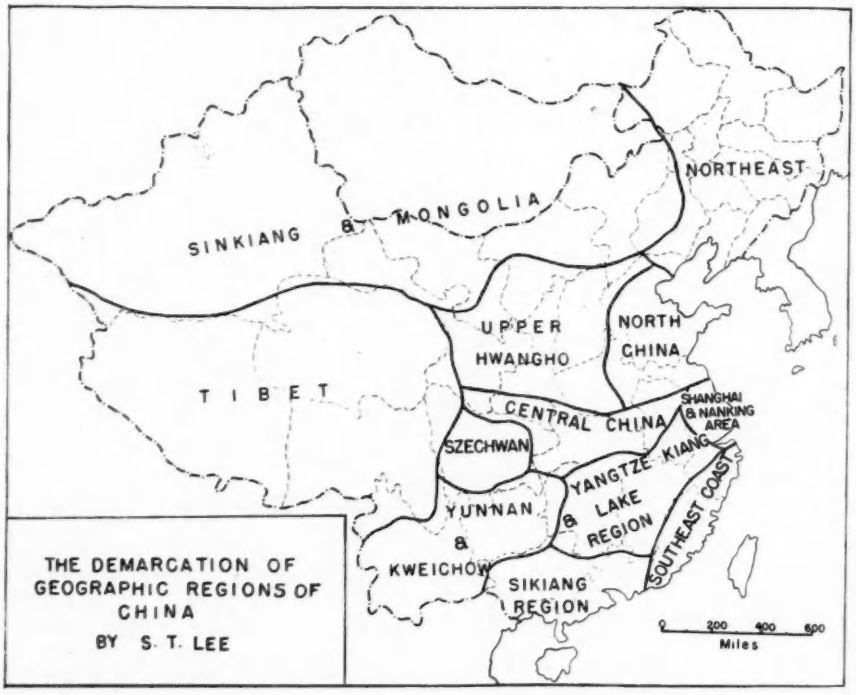

FIG. 9. Delineation of the geographic regions of China, by Shu-Tan Lee.

[9] The percentage of the land which is cultivated in Kirin is 18.4, in Heilungkiang 9.0, in Liaoning 14.5, and in Jehol 8.8. See *Statistical Analysis of Land Problems in China*, published in Chinese by the Statistical Bureau, National Government, 1944.

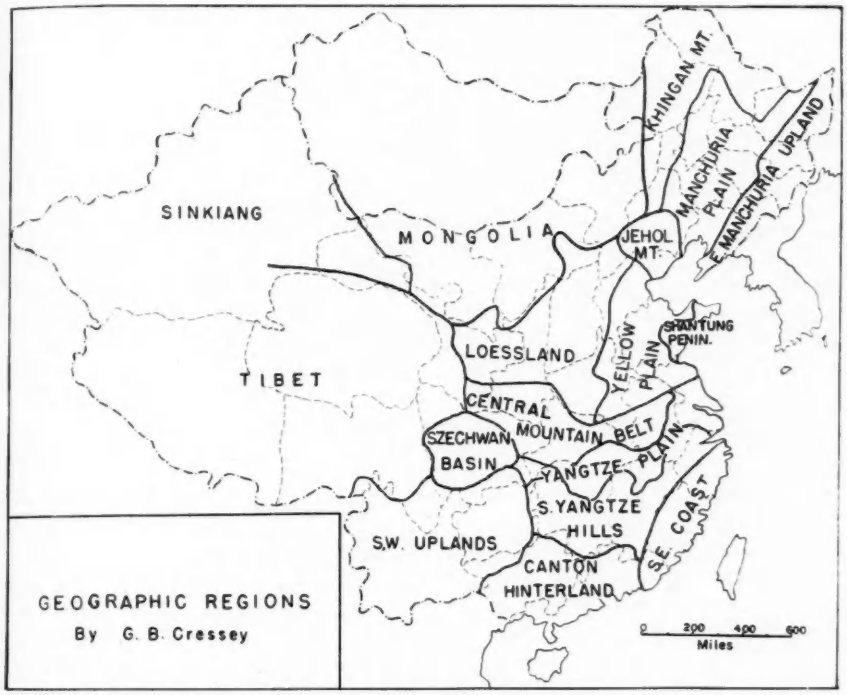

FIG. 10. Geographic regions of China according to George B. Cressey.

TIBET REGION

South of Kunlun and west of the Tibetan border ranges lies the lofty plateau of Tibet at an elevation of 10,000 to 15,000 feet above sea-level. The vegetation is mountain tundra, soil thin, yearly mean temperature below zero, growing season less than 90 days, and annual rainfall ranging from 20 to 40 inches. Some agriculture is practiced in local valleys with less than half of 1 per cent of the land cultivable. There are pasture lands in its northeastern area and some forests along the southeastern border ranges.

THE UPPER HWANG-HO REGION

Located south of the Inshan and Great Wall, north of the Tsingling and west of the Taihang range, this is a dissected plateau mostly above 3,000 feet, drained by the Hwang-ho and its tributaries and covered by thick and fertile deposits of loess. Winter is cold with growing season less than 200 days. Annual rainfall ranges from

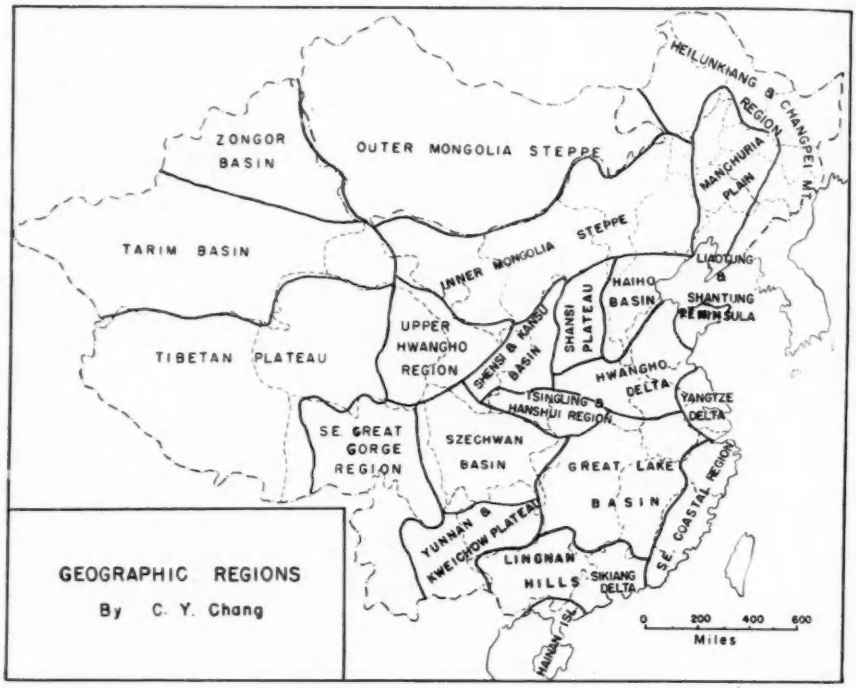

FIG. 11. Geographic regions of China according to Chi-Yun Chang.

15 to 20 inches, with great variability. About 20 per cent of the land is under cultivation, chief crops being winter wheat and millet. There is little forest, but the region contains the richest coal fields of China.

NORTH CHINA REGION

Located south of the Great Wall, north of the Hwai-ho and west of the Taihang range, North China is a farmland of large, flat, low and rich alluvial plain laid down by the deposition of the Hwang-ho, Hai-ho and other waters. The land nowhere rises above 1,000 feet. Winter is cold and summer hot. Annual precipitation amounts to 20 to 30 inches, with great variability from year to year associated with frequent droughts and floods. The growing season ranges from 200 to 250 days. Winter wheat, kaoliang, beans, millet, and cotton are the chief crops. Nearly 50 per cent of the land is under cultivation.

CENTRAL CHINA REGION

This region comprises a transitional belt south of the Tsingling-Hwai-ho line and north of the Yangtze. For the most part hilly, it is covered with calcareous gray-brown forest soil and remains moderately forested. Annual precipitation averages around 30 inches. Cultivated land occupies about one fourth of the total area. Rice, wheat, and millet are the chief crops.

THE YANGTZE-KIANG AND LAKE REGION

This includes the middle Yangtze valley, the lake districts, and the tributary river valleys in Hunan and Kiangsi. The region is composed of low hills of lateritic soil and alluvial plains along the numerous lakes and rivers. Here summer is very hot and winter mild. With a long growing season of 300 days or more and abundant rainfall of from 40 to 60 inches a year, this is called the "rice bowl" of China. The hills are only partly forested, with some hillsides planted to tea shrubs. About 15 per cent of the land is cultivated. The region is rich in deposits of tungsten and antimony.

SZECHWAN REGION

Szechwan is a basin of purplish soil, below 3,000 feet in elevation, surrounded by high mountains, drained by the Yangtze and its tributaries. It has hot summers and mild winters, with growing season extending as long as 300 to 360 days. The region is moderately forested with about 25 per cent of the land cultivated. Chief crops are rice, wheat and maize.

YUNNAN AND KWEICHOW REGION

Located east of the Tibetan Border and west of its plateau rim, the surface is deeply dissected, with summit heights of 6,000 feet. The plateau embraces many fertile intermont basins. The soil is thin and lateritic in character. Yearly temperature range is small, with mild winters and cool summers. Annual rainfall ranges from 40 to 60 or more inches, with great local variations. Growing season is 300 days or more. About 8 per cent of the land is cultivated, chiefly to rice and maize.

THE SIKIANG REGION

South of the Nanling range and east of the Yunnan-Kweichow plateau rim lies the Sikiang region drained by the Sikiang or the Pearl River and its tributaries. The land is hilly, covered with lateritic red earth. Climate is subtropical, snow unknown and frost rare, the annual rainfall is 60 to 80 inches. Double cropping of rice is practiced. Owing to the hilly topography, only 10 per cent of the total land area is cultivated.

THE SOUTHEAST COASTAL REGION

This includes Fukien, south Chekiang and north Kwantung, a mostly hilly country with short, rushing streams and narrow coastal plains. The region is covered with lateritic forest soil. Winter is mild with rare snowfall. Annual rainfall ranges from 45 to as heavy as 80 inches. Chief crops are rice and tea, with less than 15 per cent of the land cultivable.

THE SHANGHAI AND NANKING AREA

Located on the Yangtze delta north of the Tsientang River and south of the Hwai-ho, this area deserves special attention. It has rich and inexhaustible alluvial soil, adequate and reliable rainfall of 30 to 40 inches a year and a temperate climate. In addition to its abundance of farm products (rice, wheat, and cotton), this is a region of high industrial development facilitated by the accessible capital and the cheap transportation of the Yangtze estuary and the network of innumerable rivers and canals. More than 50 per cent of the area is cultivated.

CONCLUSIONS

The geographic regions of China thus delineated seem to possess several advantages over both of the previous classifications, proposed by George B. Cressey and Chi-Yun Chang.[10] (See Figures 10 and 11.)

First, the method employed for the delimitation is more objective and, therefore, less likely to be involved in subjective controversy.

Second, the boundaries delineated possess at least four common physical and cultural characteristics so that each region is sufficiently uniform in itself and distinct from others.

Third, the regions are easy to subdivide. Any smaller-sized girdle of two or three lines in combination could be taken as a boundary for marking sub-regions, such as the Tarim, the Tsiadam, the Sungari-Liao, the Sikiang delta, the Jehol, the Shantung Peninsula and the Leichow Peninsula and Hainan Island.

Fourth, these regions of more or less uniform characteristics are useful as units for planning the post-war economic development. Since regional specialization is the keynote of regional reconstruction, various plans should be laid out for each region to match its particular conditions and special requirements, thus to bring forth better adjustment between earth and man.

[10] George B. Cressey: *China's Geographic Foundations*, 1934, and *Asia's Land and Peoples*, 1944; Chi-Yun Chang: "The Distribution of Chinese People," *Journ. Geog. Soc. of China*, Vol. 2, No. 1 (1935).

A NEW MAP OF THE CLIMATES OF CHINA

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University of Wisconsin

COLLECTIONS of precipitation and temperature data published during the past few years have made a revised map of the climates of China both timely and feasible. Records used for this study were published mainly in two Chinese volumes, *Climatological Data—Temperature* and *Climatological Data—Precipitation*,[1] and in Dr. Erwin Biel's comprehensive *Weather and Climate of China*.[2] Some records for places in Sinkiang, provided by T. Y. Chow, were also referred to. Stations for which, in most cases, both temperature and precipitation records were used in this study are shown in Figure 1.

The accompanying map of climatic types (Fig. 2) follows a slightly modified Köppen classification. Mean January temperature of 32° instead of 26.6° F. is used to define the C–D boundary. The symbols, Caf-1 and Caw-1, indicate the part of south China with absolute minimum recorded temperatures 32° F. or above. Köppen symbols are used in the order adopted by Trewartha.[3] Many of the temperature and precipitation records are not simultaneous; however the most weight was given records for the longest and most nearly comparable periods. Much would be lost in a study of this kind by failing to use all available data. All data were plotted on relief maps of China.[4] Thus the approximate elevation of each station and the general orography of its environs were known. Boundaries were first drawn to climatological data; they were then adjusted in terms of orography wherever necessary.

Two principal facts emerge from the study. First, when this slightly modified Köppen classification is applied to recently published data now available, the resulting

[1] Published by the National Research Institute of Meteorology, Chungking, 1943–44. These are the most complete assemblages of Chinese temperature and precipitation data available at present. They contain monthly and annual temperature and precipitation averages for over 350 stations, either temperature or precipitation averages for some 400 more places, and records of temperature and precipitation extremes.

[2] Published by the U. S. Army Air Forces Weather Division, Washington, 1945. The volume includes 475 pages of climatic tables and many maps of climatic elements.

[3] Trewartha, G. T., *Introduction to Weather and Climate*, New York, 1943.

[4] Ting, V. K., and Wong, *New Atlas of China*, 1934.

This paper, based on instrumental records recently made available, is sponsored for publication by Glenn T. Trewartha of the University of Wisconsin. For a further treatment of this general theme see "Climate and Man in China," by Chi-yun Chang, *ante*, Vol. xxxvi, March, 1946, pp. 44–73.—Ed.

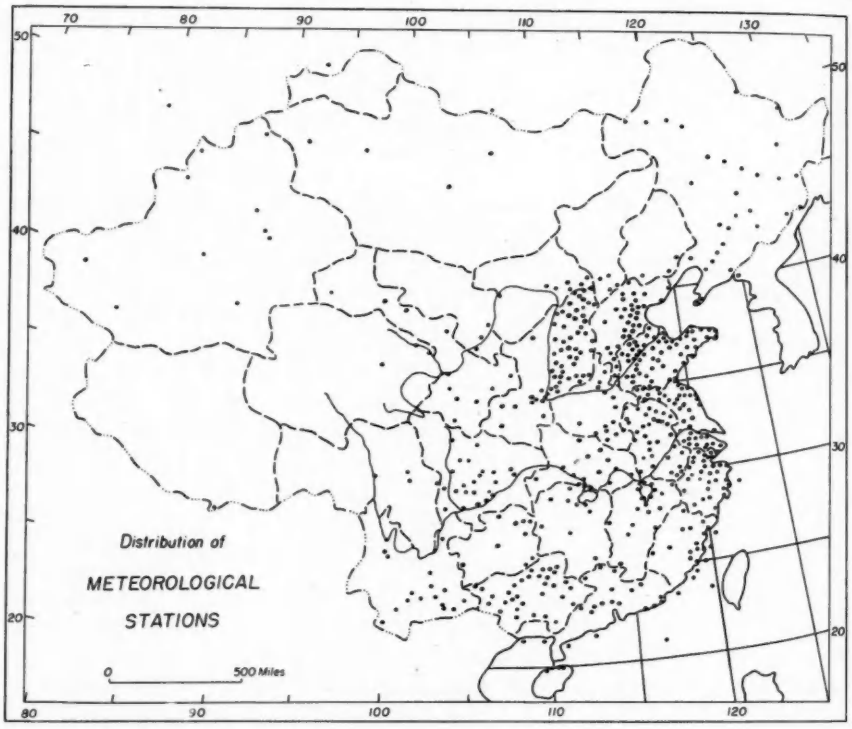

FIG. 1. Location of recording stations in China.

map portrays clearly the contrasting climatic realms in China essential to a knowledge of the general geography of the country. Moreover, not only are the dry realms of China set off from the humid and sub-humid realms by the great mountain ranges that oppose the summer monsoonal flow, but also the sub-humid microthermal north and the humid mesothermal south in China-proper are characterized by important differences in atmospheric circulation and airmass controls. Second, the Yellow River plain of northeast China, previously indicated as humid on maps published in the United States, has a BSk type climate.

MAJOR CLIMATIC REALMS

In eastern China (or China-proper) the classic geographic boundary zone between north and south appears as both a temperature and a rainfall boundary. This boundary zone is more than an important cold-month temperature boundary; it is the southern limit of occurrence of occasional steppe years, indicating its importance

as a boundary zone of rainfall amount and reliability. It is also an important airmass transition zone during the summer monsoon.

From the Yangtze plain southward is a realm in which convergence and overrunning of tropical maritime (mT) air along the polar front, as it migrates northward in spring, produce abundant rain (10–30 inches in March, April, and May). Thereafter, convergence of two moist airmasses—tropical maritime and more humid equatorial maritime (mE)—along the equatorial front produces equally abundant summer rainfall (Fig. 3). In contrast, northeast China (the "D" climates and the Yellow River plain) depends mainly on one humid summer airmass—tropical maritime—and

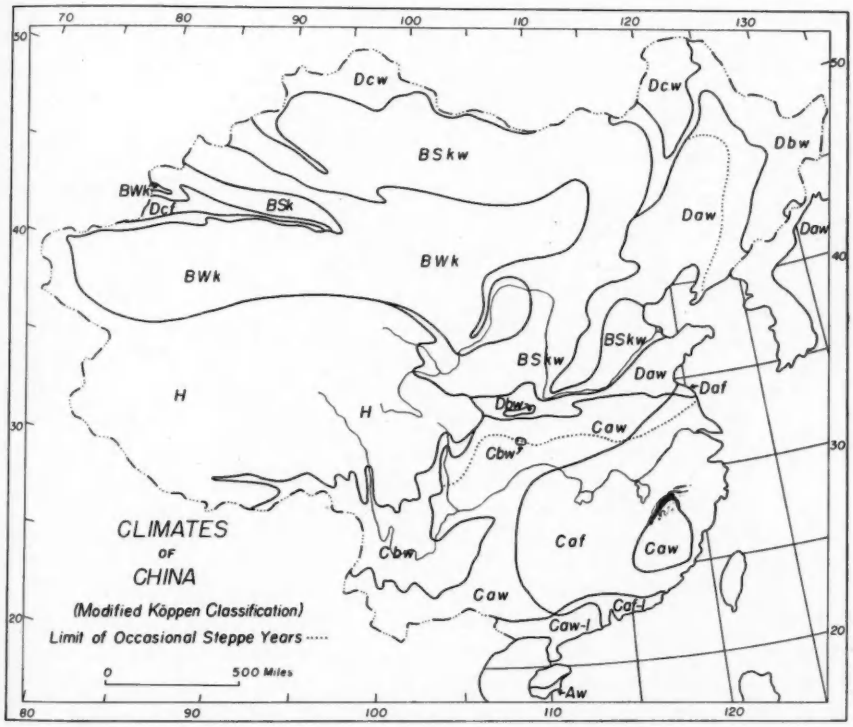

FIG. 2. The climatic types shown are those of Köppen with the following three exceptions: January mean temperature of 32° F. is used to define the C–D boundary. The number "1" is added to the Caf and Caw symbols in the part of south China in which no station has recorded a minimum temperature below 32° F. The letter "H" pertains to highland regions where data are inadequate and detail too great to permit bounding the Köppen types known to exist there. The H area includes the E climates of the high Tien Shan, the E and B climates of Tibet, and the BS, Db, and Dc climates of eastern and southeastern Sikang.

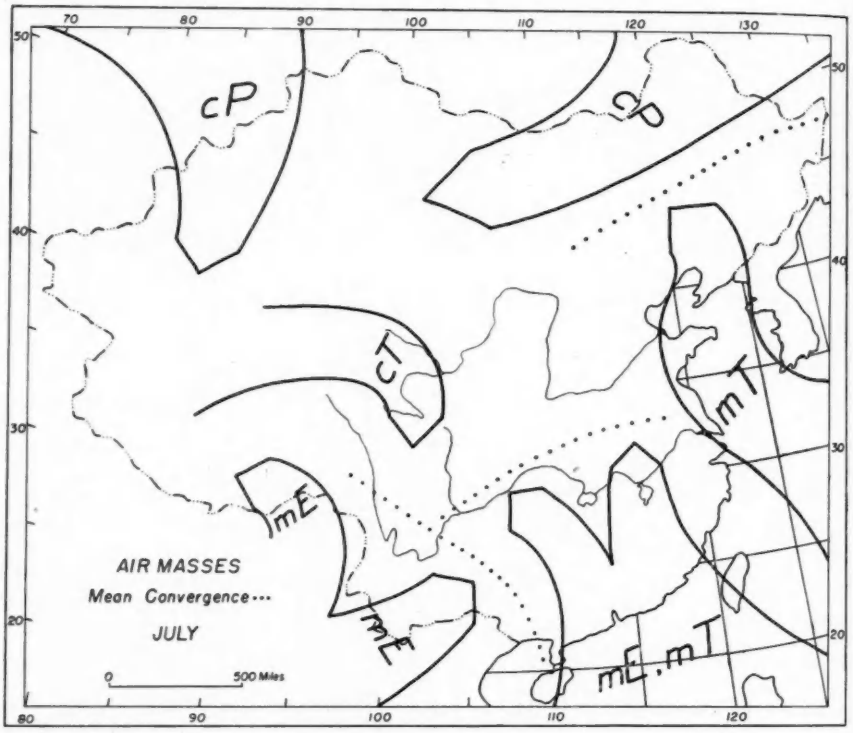

FIG. 3. The convergence zones shown are areas more frequented than others by cyclonic and frontal activity. Differences in the character and persistence of the summer airflow are important controls differentiating the climates of eastern China. The map is schematized from streamlines of mean July resultant surface winds drawn by the author using data from Biel (*op. cit.*), and also from scattered reports of prevailing winds at places in western China from Biel and Chow.

the polar front for its rainfall. The realm north and northeast of the boundary zone at the Hwai plain is affected much less than the south of China by the polar front in spring (generally less than 4 inches of rain during March, April, and May). In summer the polar front migrates north to a mean position within the northern part of this northeastern realm. Thus northeast China lies in the broad boundary zone of the southeast monsoon, where the inflow of tropical air yields occasionally to an outbreak of polar air from northeast Siberia or the Sea of Okhotsk. Convergence and overrunning along the polar front are the northeastern realm's vital rain-makers. But the front sojourns there relatively briefly (mainly in July and August) and with notorious inconsistency in its mean latitudinal position. The zone of the C–D boun-

dary in China east of about the 105th meridian, then, in addition to being the mean position of the 32° January isotherm, is a threshold of mean rainfall amount and variability and climatic controls. It is perhaps a *complete* climatic boundary.[5]

Within the sub-humid, microthermal northeast the map distinguishes the highlands and northlands of Manchuria, where summers are cool (Db, Dc) because of high elevation, high latitude, or predominance of polar air throughout the summer (Fig. 3).

In the humid, mesothermal south rainfall is everywhere abundant and relatively reliable, although mean variability is greater than in the corresponding part of North America.[6] Temperature boundaries set off the Yunnan plateau and the large valleys to the west, where summers are relatively cool and there is no winter monsoon. In the far south (Caf-1 and Caw-1) no meteorological station has yet recorded a temperature below 32° F. In this relatively frost-free part of China broadleaf evergreen trees dominate in the virgin forests.

The vast expanse of dry China (BS, BW) reaches to Middle Asia from the landward sides of the great mountain chains from the Trans-Himalaya in the southwest to the Great Kinghan in the northeast. Outside monsoon China, moisture for the humid "islands" on the western mountains (Fig. 2) is wrung the year around from the westerlies.

THE DRY CLIMATES OF NORTHEAST CHINA

Since the BSk type climate has not previously been extended right to the east coast on the North China plain on American climatic maps, it is appropriate to examine more closely the eastern boundary of the dry climates in northeast China.

Of particular interest are the results of a study of steppe and desert years in northeast China for the 20-year period, 1913–1932.[7] In general the southern limit of

[5] For discussions of Chinese airmasses, see Biel, E. R., *op. cit.*, pp. 5–8, and Finch, John V., et al., *Weather and Climate of China* (Part C), USAAF Weather Division, 1945. The author is indebted to Dr. Reid A. Bryson of the University of Wisconsin for the use of a series of synoptic weather charts for southeast Asia for July.

[6] The distinction between Caf and Caw in south China appears to be of relatively little importance. The southern and southeastern slopes of the Nan Ling ranges, with a "w" (winter-drought) rainfall characteristic, actually receive more winter precipitation than stations to the north and west with an "f" characteristic. But the former receive excessive summer and spring rainfall, while the latter are in the Nan Ling rain shadow during the southeast monsoon period.

[7] The study is based on data for the same period or parts thereof from 45 stations, published by Co-ching Chu, Chang-wang Tu, and P. K. Chang in *The Chinese Rainfall*, Nanking, 1935. It was practical to use some incomplete records. For example, a station which experienced one steppe year in 12 has one in 20 but must have fewer than 10 in 20. Russell (see footnote 8) recognized the fact that 20 years may not represent a climax period, but the Chinese data could not be stretched over a longer period. Present data in the interior are inadequate for locating areas of all steppe or all desert years. Deficiency of data also necessitated substituting the long-time average annual temperature at each station for the actual averages for individual years in

steppe-year occurrence in eastern China (Fig. 2) during the period examined corresponds to the isarithms of 20 per cent mean annual and 30 per cent mean spring rainfall variability and follows the Tsinling-Tapashan ranges.

The Yellow River plain has a very high frequency of steppe years. For example, Tientsin, on the border of the BSk area, experienced 12 steppe years and one desert year in the 20-year period. In the driest part of Hopeh province, Tinghsien (38.5° N., 116.0° E.) had one humid, one desert, and 11 steppe years in a 13-year period. At Hsienhsien (38.2° N., 116.1° E.) a 14-year record included one desert and 13 steppe years. Occasional dry years are experienced in Manchuria and Shantung up to 300 to 400 miles east of the steppe-humid boundary. To the south the Tsinling rain shadow effect draws the steppe-humid boundary and the occasional-steppe-year boundary within 200 miles of each other (Fig. 2). In general this is similar to the North American situation. Russell mapped the limit of occasional steppe years from 250 to 400 miles east of the steppe-humid boundary on the Great Plains.[8] The areal range of occurrence of occasional desert years in the two areas is also comparable. It is interesting to note that desert years have occurred eastward to the coast of the Gulf of Chili. The data indicate that the area of 11 to 20 steppe years and of one to 10 desert years in 20 coincides with the area of BSk climate. Since the boundaries would be identical with the steppe-humid boundary in Figure 2, no separate map of frequency of steppe years is included.

The Hwang Ho plain area of steppe interrupts the "D" climate region of northeast China. The entire plain has heretofore been generally considered humid, although its aridity has been recognized by Wissman and Lu.[9] The landscapes of the Yellow River plain, especially its intensive agriculture, are not the sort usually associated with dry climates. Yet the criteria of both Köppen and Thornthwaite, applied to available data, indicate that the area has a dry climate. Tientsin, with an average annual rainfall of 21 inches and yearly average temperature of 54° F., is typical of the humid boundary of the zone. Hsienhsien is typical of the core; it has annual temperature and rainfall averages of 55° and 15 inches, respectively, for a period of 15 years, compared with 46° and 17 inches for Pierre, South Dakota. The average precipitation effectiveness, according to Thornthwaite's system, in this part

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Köppen equations for determining the dry-humid boundary. The assumption that these two values were equal may introduce an error of up to 50 miles either way in placing a boundary on a plain. This would make no significant difference in the map, and it is probably a negligible error when one is working with Chinese data.

[8] Russell, R. J., "Dry Climates of the United States, II," *Univ. of Calif. Publications in Geography*, Vol. 5, No. 5 (1932), pp. 245–74.

[9] See Wissmann, Hermann, "Die Klima- und Vegetationsgebiete Eurasiens," *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, Apr., 1939, pp. 1–13; also A. Lu, "The Climatic Provinces of China," *Jour. of the Geogr. Soc. of China*, Vols. 12–13 (1945–46), (Chinese with English translation).

REVIEWS AND ABSTRACTS OF STUDIES

THE RUSSIAN SUBARCTIC

Grigoryev (Grigor'iev), A. A.; *Subarctica; experimental characteristics of the principal types of the physiographical environment,** Academy of Science of the USSR, Moscow-Leningrad, 1946. 171 pages.

In the brief introduction to his monograph, the author points out that this book represents one of the series of papers which he began to publish in 1938 under the general title "Essay on characteristics of the principal types of physico-geographical environment." The author's general plan, as announced in the first published paper of this series, was to describe "all principal types of physico-geographical environment . . . from the standpoint of the processes and their energy which take place in them, as well as the general character of the balances of matter and energy." It was hoped that, having all the types of environment on the earth described, it would be possible to establish the fundamental principles of their development.

Before the war the author published several short sketches on the environments in the Equatorial, Tropical, and Arctic belts and an introduction to the systematic study of the Subarctic and Temperate belts ("Problems of Physical Geography," Issues V, VI, VII, and XI). The Subarctic belt is described in the latest monograph in greater detail than the others because a large part of this belt "is within the borders of the USSR and the rather detailed description of it has considerable theoretical and practical interest to us."

* This work has recently been recognized by the Stalin Prize, awarded annually for outstanding accomplishments in the arts and sciences. The announcement in the Information Bulletin, published by the Embassy of the USSR (July 9, 1947, Vol. VII, No. 11), reads as follows:

"The noted explorer Academitian A. Grigoryev, head of the Academy's Institute of Geography, was awarded a Stalin Prize for his monograph entitled *The Subarktica*. By profound scientific analysis, Academitian Grigoryev discovered the main tendencies and rules governing the development of nature in the Subarctic. This extensive study of the vast, grim region of the northern Tundra of the Soviet Union will play no small role in the further development of this area."

The author selected the region of the Bol'shezemel'skaya Tundra in the northeastern corner of the European part of the USSR and the islands of Vayigach and Novaya Zemlya as the type-location of the subarctic geographical complex, and the greater part of his discussion refers to the "East European sector of Subarctica" in which the Bol'shezemel'skaya Tundra is located. In this region the northern and southern boundaries of the subarctic belt approximately coincide with Lat. 73.2° N. and Lat. 67.1° N. respectively. Grigoryev divides this belt at about Lat. 69.8° N. into two zones, northern or subarctic proper, and southern or subboreal.

The most important regional variants of the East European subarctic complex, the East Siberian, Far Eastern, Western or Murman, and North American are described in chapter VIII, the first three in considerable detail. Due to the lack of information available to the author, the North American discussion occupies less than one page of a 34-page chapter.

The monograph consists of eleven chapters dealing with: (1) boundaries of the subarctic belt and its subdivision into the zones; (2) climate; (3) hydro-geomorphological process; (4) processes of soil formation; (5) vegetation; (6) fauna; (7) combinations of principal energy factors and balances of the most important classes of matter; (8) the most common variations of the physico-geographical process on the subarctic plains; (9) vertical zonation in subarctic mountains; (10) evolution of the subarctic physiographical environment, and (11) some of the most important conclusions. At the end of the text is a list of references including 180 works, mostly Russian.

The general character of this interesting and stimulating book is determined by the author's approach to his subject. He is concerned largely with the dynamics of development of various components of the subarctic geographical complex rather than with the results of such developments. For example, the 30-page chapter on vegetation and its ecology deals mainly with the adaptation of plants to the peculiar conditions of Subarctica such as low temperature, intense radiation (insolation) and excess of ultraviolet rays during the growing season, and deficient nutrition, as well as the influence of subarctic conditions, depth of snow,

relief, drainage, permanent ground frost, and other factors upon the forms and distribution of plant life. Several pages are devoted to the evolution of the Tundra phytocenoses and the forage value of various plants upon which the subarctic animal life largely subsists.

The chapter on vegetation is typical. The same treatment of various other aspects of Subarctica is characteristic of the entire monograph. In the chapter dealing with the soils, the reader will find little systematic description of even the most common types. Most of this chapter is given over to the discussion of the peculiar conditions of weathering and soil formation in the subarctic regions. Considerable space is devoted to the influence of ground frost, low temperature, and the predominance of mechanical over chemical weathering.

The greater part of the chapter on fauna deals with the adaptation of the animal life to the rigorous environment of Subarctica.

The subarctic environment is characterized especially by the low temperature and the negative annual balance of radiational energy. During the warmer part of the year, from April to August, the mean monthly balance of radiation in calories per square centimeter of horizontal land surface at Lat. 69° N. ranges from +42 in June to −142 in August. The range at Lat. 73° N. is from −1.5 in June to −147 in April. Such low and predominantly negative balances of thermal energy are due in part to the loss of heat through the strong long-wave radiation from the earth during the summer and in part to the consumption of heat by melting of snow and thawing of frozen soils. Calculation shows that melting of a column of soil one meter deep and one square centimeter in cross section containing 30 grains of ice (0.3 gr. per 1 cc.) requires 2400 calories. The amount of heat consumed, naturally, increases with the ice content.

Permanent ground frost is one of the most significant conditions in the development of the hydro-geomorphological process in Subarctica. The thickness of the frozen ground in the East European part of Subarctica, and very likely throughout the belt, increases from West to East as well as from South to North.

The depth of melting during the summer ranges from about 30 centimeters to about 2 meters. The most effective or deepest defrosting is found in well-drained, sandy soils. In general, the better the drainage the more effective the defrosting of the soil if all other conditions are similar.

Freezing during the winter is also uneven. It was found that in the Bol'shezemel'skaya Tundra the ground does not freeze at all under heaps of drifted snow 3 meters or more in thickness. Nor does freezing affect the bottom of lakes and rivers, if they are sufficiently deep.

The deep freezing of the ground, together with a rather shallow defrosting of the surface of the permanently frozen layer, probably more than any other single factor affects the general character of Subarctica. It affects the regimen of rivers, erosion, the general trend of soil formation, the development of a peculiar micro-relief (to the discussion of which eleven pages of the Grigoryev monograph are devoted), the character of vegetation, animal life, and especially the annual balance of thermal energy.

The balance of living organic matter is discussed in Chapter VII. The author states that the character of such a balance can be judged on the basis of annual production of organic matter by the plant and animal life and the ability of a given area to support all animal life inhabiting this area throughout the year.

The balance is "neutral" if the area supports its own animal population; "positive" if, in addition to its own population, it supports some seasonal migrants from the poorer regions; and "negative" if it does not support the annual propagation of its own animal life.

Subarctica is visited every summer by a large migration, especially of migratory birds. These, however, largely subsist on food obtained from seas, lakes, and rivers, not on land food. The situation regarding the land life is different. In the conclusion of his analysis of the dynamics of subarctic fauna, Grigoryev states that on the annual basis "the East European Subarctica could support not more, by any means, than 30 to 40 per cent of its summer population and perhaps even less. A large part of this percentage, perhaps about one-half, and in the subarctic zone proper probably even more, subsists on food obtained from water. Such a conclusion is based on the fact that "by far the greater part of the largest mammals and birds born in Subarctica migrates to winter in other zones, whereas the large part of the invertebrata either dies in the fall or becomes dormant." Thus the annual balance of living matter in the plant-and-animal system in Subarctica is decidedly negative.

As pointed out above, Grigoryev's book deals almost entirely with the subarctic regions of the USSR. Nevertheless this monograph undoubtedly will be of great interest to every

geographer, not only those specifically concerned with Subarctica, but also those who might be interested in methods of systematic analysis of a "physiographical environment." It is entirely possible that not all Grigoryev's conclusions will be readily accepted by the readers, but still his work is an extremely valuable contribution to geographical science and thus deserves serious attention.

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THE ARCTIC INSTITUTE OF NORTH AMERICA: STUDIES IN PROGRESS

The studies in various fields of Arctic research that are currently being carried on through the Arctic Institute of North America may be divided into two groups: those being supported directly by the Institute and those for which funds have been made available by governmental agencies in the United States and Canada.

To date, six Fellowships, varying in amount from $1,000 to $2,000, have been awarded by the Institute. In 1946 three such awards of $1,500 each were made to Mr. Harold C. Hanson of the Illinois Natural History Survey, Dr. Margaret Lantis of Washington, D. C., and Dr. Nicholas Polunin of Oxford and McGill Universities.

Mr. Hanson is studying the nesting habits of the Canada Goose in the James Bay region. A preliminary survey of the area was made by Mr. Hanson in 1946 and he has returned to the field for further work in 1947. The results of his investigations will be combined with those of other wildlife workers who have been making a study of wintering conditions for Canada Geese in the entire Mississippi Valley.

Dr. Lantis is an ethnologist who, in 1939–40, spent a year among the Eskimos on Nunivak Island, Alaska. Two parts of a projected five-part study on her findings were published in 1946 by the American Philosophical Society. The grant awarded to Dr. Lantis by the Arctic Institute enabled her to return to Nunivak Island for several weeks in the summer of 1946. In this time she was able to bring up to date the genealogies of various families on the island as well as to give certain personality tests to both adults and children. The results of her investigations will be embodied in reports on the Technology and Art, Personality and Acculturation of the natives of Nunivak Island.

The Fellowship awarded to Dr. Polunin permitted him to spend the summer field season of 1946 in the Canadian Eastern Arctic studying the botany of the region. The material he gathered will be used by Dr. Polunin to complete his "Botany of the Canadian Eastern Arctic," several parts of which have already been published.

One of the 1947 Fellowships was awarded to Dr. Ilmari Hustich of the University of Helsinki, Finland, for botanical and forestry investigations along the east coast of Hudson Bay. He will be assisted by Dr. R. Tuomikoski and two botanists from the National Herbarium of Ottawa. The other 1947 Institute Fellowship has been divided between Dr. Jacques Rousseau, Director of the Montreal Botanical Garden, for botanical work on Ungava Peninsula, and Mr. R. D. Slobodin of New York City who has been carrying out ethnologic investigations in the vicinity of Fort McPherson, Mackenzie Valley.

Applications for two Fellowships of $2,000 each for field work to be done in the North American Arctic or Subarctic in 1948 are now being invited. Additional information and application forms may be obtained by writing to the Institute at 805 Sherbrooke Street West, Montreal, Canada. Final date for receipt of applications is November 1, 1947; the awards will be announced by March, 1948.

In addition to the scientific work made possible by the Research Fellowships, the Arctic Institute will be sponsoring a number of scientific projects in co-operation with governmental agencies in Canada and the United States. Funds have already been allocated to the Arctic Institute by the Canadian Government for studies of northern Canada covering physical geography, oceanography, and wildlife. Other studies, to be supported by contractual arrangement between the Arctic Institute and the Office of Naval Research in Washington, will cover research in biology, wildlife economics, and geology. It is anticipated that the results of all the above studies will be published in appropriate scientific journals.

The Institute is also undertaking the preparation of a comprehensive bibliography on the Arctic and a roster of Arctic specialists by contractual arrangement with the Office of Naval Research and with the support of the

War Department. The bibliography will be indexed according to author, subject, and geographical region and will, it is felt, be an important scientific research asset. The roster of Arctic specialists will list personnel who have had experience in the Arctic and will be indexed according to fields of specialization. It is expected that two years will be required to complete the roster and three years to prepare the bibliography.

A book entitled "The North American Arctic," containing chapters on various scientific subjects, each written by a specialist in his own field, is now in the course of preparation under the sponsorship of the Institute. It is being edited by Dr. L. M. Gould and is scheduled to be published late in 1947.

By facilitating and supporting studies such as those outlined above, the Institute hopes to achieve its objective of broadening scientific knowledge of the Arctic.

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POSTGLACIAL CLIMATIC HISTORY

Hansen, Henry P.: "Postglacial Forest Succession, Climate, and Chronology in the Pacific Northwest," *Transactions American Philosophical Society*, N.S., Vol. 37 (1947), pt. 1, 130 pp., 114 figs.

Investigation relating to the course of postglacial climatic history has in the last few years been making rapid progress. Evidences from various fields have been fitted together into a single pattern, very generalized, it is true, but consistently similar in every region studied. With deglaciation and following it the climate became warmer and almost always drier. This trend reached its culmination in the "warm-dry" period of mid-postglacial time; since then the climate has become cooler and moister.

The initial evidence for this progression came from plant fossils. Peat stratigraphy was first utilized; later came the method of pollen analysis, which has yielded rich results. First practiced in Europe, the method has been considerably exploited in northeastern America. Western America lay practically untouched until H. P. Hansen, single-handed, took on the Pacific Northwest, a region extraordinarily diverse in topography, climate, and vegetation. In the space of nine years 26 papers dealing with limited areas appeared under his name. The present comprehensive work, summarizing and interpreting the voluminous data obtained, is an outstanding contribution.

Seven diverse unit areas are treated: the Puget Sound region, the coastal strip, the Willamette Valley, eastern Washington, northeastern Washington and northern Idaho, the Oregon Cascades, and a small portion of the Great Basin. In all but one of these there is definite evidence of the warm-dry period. Each unit area has its own characteristic indicator of this episode, appropriate to its climate. In the Puget Sound region it is Douglas fir, in the Willamette Valley Garry oak, in the Oregon Cascades ponderosa pine, in eastern Washington and northern Idaho and in the Great Basin grasses and chenopods, many of the latter being characteristic of saline soils. The evidence, though diverse, is consistent and convincing. The lone exception to parallelism in climatic history is the coastal strip of Washington and Oregon where, because of oceanic influence, one would not expect a trend toward warmth and dryness to produce an appreciable effect.

Hansen has made good use of a feature that is perhaps unique in pollen studies to date—the presence in the profiles of layers of volcanic ash and pumice. Certain of these, particularly the one associated with the great eruption of Mount Mazama, could be identified over wide areas. Such a horizon serves as a useful time marker. The portions of the profiles above the ash horizon, provided the surface is undisturbed, represent the same lapse of time regardless of thickness. The equivalence of the portions below is less certain. Incidentally, the study aids in the dating of the eruption of Mount Mazama. The pollen records show that it occurred before the maximum of the warm-dry period, and correlation with other types of evidence indicates that the event took place not more than 10,000 years ago.

Hansen has linked his results with those of others who have worked on the more strictly geologic aspects, particularly with the studies of I. S. Allison. We may confidently expect further significant findings in this region, so rich in possibilities.

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THE WORK OF THE WIND

Chepil, W. S.: Dynamics of Wind Erosion: I. Nature of Movement of Soil by Wind; II. Initiation of Soil Movement; III. The Transport Capacity of the Wind; IV. The Translocating and Abrasive Action of the Wind; V. Cumulative Intensity of Soil Drifting Across Eroding Fields; VI. Sorting of Soil Material by the Wind; in *Soil Science*, Vol. 60 (1945), Nos. 4, 5, 6: 305–20, 397–411, 475–80 and Vol. 61 (1946), Nos. 2, 3, 4: 167–77, 257–63, 331–40.

The capacity of the wind to carry, deposit, and abrade earth materials is of both practical and academic interest, whether it be erosion of soil in a farmer's field, origin of loess deposits, shaping of a barchan, drift of sand across a highway, or the corrasion of a boulder. Early mention of aeolian erosion was made by such men as Wellsted (*Travels in Africa*, 1838), and Élie de Beaumont (*Leçons de Geologie Pratique*, 1847). Somewhat later, Blake (Explorations in California for Railway Routes, *33rd Congr., 2nd Sess., Exec. Doc. No. 78*, 1856) described the results of wind action in parts of the Colorado Desert, especially in the lower portion of San Gorgonio Pass. Of studies of wind work in more recent years, perhaps the most significant is that of Free (The Movement of Soil Material by the Wind, U.S.D.A., Bureau of Soils, *Bull. No. 68*, 1911). Free's monograph represents a broad consideration, encompassing many things—from sand-drift and whirlwinds to soil erosion and volcanic dusts—and including an exhaustive bibliography of aeolian geology.

Of current interest is the meticulous work of W. S. Chepil, agricultural scientist, Dominion Experimental Station, Swift Current, Saskatchewan. His series of six articles, cited above, is in part extremely technical; however, each paper has a short, straightforward summary which is very helpful to the non-expert. In many ways, Chepil's studies constitute a modern continuation of Free's investigations. Essentially they represent a search for results capable of wide application to the problem of erosion of many kinds of soils by wind. Hence, they are not necessarily limited to the work of wind in arid and semi-arid regions, as so often has been the case. Chepil draws heavily, in terms of dynamics, upon the also recent work of Bagnold (*The Physics of Blown Sand and Desert Dunes*, Methuen and Co., Ltd., London, 1941). While much of Bagnold's investigation was based primarily on wind-tunnel experiments, Chepil leans heavily on direct field observation and the use of detailed photographic and quantitative measurement techniques out in the open.

The general nature of Chepil's six reports on wind erosion dynamics is indicated by the subtitles. His conclusions are too long to be restated in their entirety here; however, the following are presented as samples chosen somewhat arbitrarily from among the six articles:

> Particles of soil are moved by saltation (bouncing), in suspension, and by surface creep.
>
> Those moved by saltation travel upward from the surface on a very steep curve, before they descend on an oblique trajectory to strike the surface at a 6–12 degree angle.
>
> The amount of material moved by saltation, in suspension, and by surface creep varies greatly with soil type. In general, proportionately greater weights are moved by saltation and lesser weights in suspension and surface creep. Soils of very coarse grain move predominantly by saltation, while very fine soils move both by saltation and suspension. It is noted that soils composed entirely of very fine dusts are highly resistant to wind erosion.
>
> Because saltation engenders movement of materials in both suspension and creep, programs of erosion control should be based on methods which curtail or prevent saltation.
>
> Wind acts on soil in two general ways. It removes loose grains from the surface by direct velocity-pressure and by breaking-up and moving soil as a result of the blows incident to soil grains descending from saltation.
>
> In eroding fields, there is a gradual increase in soil movement rate as distance from the windward side of the field increases. The major causes for this are increased amounts of erosive particles, cumulative degree of abrasion, and slow decrease in surface roughness along the direction of wind movement.

This reviewer particularly wishes to call attention to discussion and definitions contained in the latter part of article IV. Here it is pointed out that soils are affected by five forms of wind erosion: effluxion, extrusion, detrusion, efflation, and abrasion. The terminology is

indicative of the precise nature of Chepil's investigations and it offers a refinement in terms which may be useful in other fields. It is interesting, for example, to note Chepil's objection to the term "deflation" and his suggestion that "efflation" be substituted.

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A FUNCTIONAL ATLAS OF WARTIME

Goering's Atlas. Office of Military Government for Germany (US), Berlin, Germany, March, 1946. 33 maps.

Shortly after the occupation of Berchtesgaden, Goering's personal papers were delivered to the Seventh Army Document Center at Heidelberg. Among them was a unique, hand-colored atlas of thirty-three maps which graphically presented the distribution of material resources and industrial installations of importance to the German war effort. The volume was originally prepared for Reichsmarshal Herman Goering for his use as the Delegate for the Four Year Plan. Compilation was undertaken in the spring of 1944 and utilized data for the years 1942–43. Because of the underlying purpose for which the volume was prepared and because of the recency of the basic information, this publication may be assumed to be more reliable than allied map intelligence of the same date of issue. It represents an unusual map appraisal of the resources available to German planning in the final years of the war. Many valuable distributional factors and patterns may be more clearly understood through an examination of this volume.

The present publication was prepared by the Map Division of the Office of Strategic Services, Mission Germany, and is a careful transliteration of the original copy. The volume suffers somewhat from a too-faithful observance of literal rendering of German legends into English. Specific reference is made to the term "coal smouldering plant" which may mean "coke oven." Misspellings of technical terms such as the proper names of minerals and glaring examples of careless construction practices related to the spelling of non-technical words mar the reproduction. The similarity of some map symbols and very bad registry, especially on the map of "Raw Material Deposits in Serbia and Greece," are confusing to the reader. In its entirety, the publication is below the compilation and construction standards usually associated with the OSS.

The atlas is divided into five groups of maps of which fifteen deal with Greater Germany, eight with the Occupied Countries of the West, three cover Denmark and Norway, four deal with the Occupied Countries of the East, and three are concerned with Serbia and Greece. A standard base map, rendered in light gray with adequate locational base data is used throughout each series, making comparisons a relatively simple matter. The base used for the Greater Germany series is on a scale of 50 miles to the inch, while the other bases are on a slightly smaller scale. Overall measurements have been set at 17″ × 24″ for the Greater Germany series, and 17″ × 15″ for the remaining maps. Despite some inadequacies in the presentation of economic data, this volume offers the student of European affairs a basic research document from which locational information of significance may be obtained. The following list of maps and legend data may serve as a table of contents for the volume.

GERMANY

Map Number and Title	Contents
1 Coal and Brown Coal	Statistical areas of Coal Mines, Brown Coal Mines, Pitch Coal, and Single enterprises; and eight categories of "potential metal content recoverable from the 1942 output of individual mines."
2 Iron and Manganese Ores	Areas of production, individual plants; six classes of output for 1942 of iron and manganese ore.
3 Nonferrous Metal Ores	Location of plants and plants under construction. Seven classes of plants on a tonnage production basis, for 1942. Metals include, Lead, Zinc, Copper, Sulphur, Arsenic, Gold, Antimony, Nickel, Silver, Mercury, Molybdenum, Bismuth, Cobalt, Tungsten, Tin, Vanadium, Cadmium, Uranium Oxide.
4 Minerals (Magnesite, Clay, China Clay, Slate, Loose Quartzite, Rock and Cement, Quartzite, Phosphorite, Bentonite)	Individual quarries. Districts with several quarries. Colored circles show scheduled war production for 1943 and actual 1942 output. Six classes of tonnage output.

Map Number and Title	Contents
5 Minerals (Barytes, Fluorspar, Feldspar, Graphite, Soapstone, Talc Slate, Pigment Asphalt, Silicate, Calcium Silicate, Mica, Bauxite, Strontianite, Lime Spar, Amber)	Individual quarries. Districts with several quarries. Seven classes of colored circles indicating scheduled war production for 1943 and actual 1942 output.
6 Potash, Rock Salt, Effervescent Salts	Location of potash mines, salt works, individual potash works, salt mines, rock salt mines, brine works. Seven classes of output for 1942 indicated by colored circles. Data divided into Potash and Rock Salt, and Effervescent salts. Bar graph shows tonnage output.
7 Petroleum, and Oil Processing Plants	Hydration works, Synthetic works, Brown coal smouldering plants, Brown coal tar distillation plants, Petroleum processing plants, Coal smouldering plants, Coal tar distillation plants, Petroleum production installations, exact centers of production, Seven classes of output indicated by circles.
8 Nitrogen, Buna and Lampblack Works	Synthetic nitrogen installations, Calcium-nitrogen installations. Buna Works, Soot works, exact locations given. Eight classes of output indicated by circles.
9 Powder, Explosives and Basic Chemical Plants	Exact location of Powder, Explosives and Basic Chemical Plants. Ten classes of plants, by tonnage per annum.
10 Nonferrous Metal Mills	Refined Copper, Crude Copper, Lead, Zinc, Tin, and Nickel mills, Aluminum and Siluminum works, Magnesium plants and concentrators.
11 Steel Mills and Blast Furnaces	Blast Furnaces, Steel works and Blast furnaces, Steel mills. Symbols classified into metric tonnage output in excess of 500,000 tons, 100,000 to 500,000 tons and less than 100,000 tons. Inset shows Rhineland production centers.
12 Amor [sic] Plate Tank Assembly Plants and Arms Factories	Information divided into major and minor centers for armor plate, tank assembly plants.
13 Aircraft Factories, Truck and Automobile Plants	Major and minor centers for Truck and Automobile Plants, and Aircraft Factories.
14 Locomotive, Tender, Railway Carriage Plants and Shipyards	Three classes each of production centers for Locomotive and Tender plants, Carriage plants and Shipyards.
15 Electric Power Plants	Three classes of plants based on production. Two insets show details of eastern and western centers (Rhine and Silesia).

OCCUPIED COUNTRIES OF THE WEST

Map Number and Title	Contents
16 Raw Material Deposits	Areal extent of coal, brown coal and iron ore deposits. Also centers of production for copper, lead and zinc, bauxite, sulphur ore, phosphate.
17 Coal and Brown Coal	Coal districts and production classified into less than 2 million tons, 2 million to 5 million tons and over 5 million tons. Brown coal production to 15 million tons. Coal mines and coke plants, Independent coke plants and Foundry coke plants. Classified by output.
18 Ore Mines.	Iron Mines, Non-ferrous metal ores, Steel refining ores, Bauxite. Classified by output.
19 Ore Processing Mills	Steel Mills, Blast Furnaces, Non-ferrous metal mills, Light metal mills. Classified by output.
20 Armaments Plants	Aircraft, Truck and Automobile, Arms and Munitions, Carriage, Locomotive plants and combined carriage and locomotive centers.
21 Oil Refining, Explosives and Nitrogen Plants	Oil processing plants, Powder plants, Primary Nitrogen (synthetic) plants, Calcium-nitrogen plants. Exact locations.
22 Shipyards	Classified according to capacity.
23 Electric Power Plants	Classified by output. 10-000 KW to 50,000 KW, 50,000 KW to 200,000 KW, over 200,000 KW

DENMARK AND NORWAY

24 Raw Material Deposits (Including Esthonia)	Brown coal, oil shale, iron, nickel, molybdenum, titian, copper, zinc sulphur ores, labradorite, mica, graphite, phosphorus. Areal extent of Brown Coal deposit in Denmark is indicated.
25 Ore Processing and Armaments Plants	Iron ores, Steel Refining ore, Sulphur ore, and Non-ferrous metals, Blast furnaces, Steel mills, Ferro-alloy plants, Non-ferrous metal mills, Light metal mills, Armaments works, Shipyards, Carriage construction, Synthetic nitrogen plants, Calcium-nitrogen plants, Oil-refining plants, Refining only. Exact locations, Two classes of output for each type of plant.
26 Electric Power Plants (Capacity over 10,000 KW)	Plants classified into 10,000 KW to 50,000 KW and over 50,000 KW.

OCCUPIED COUNTRIES OF THE EAST

Map Number and Title	Contents
27 Raw Material Deposits (Not Including Esthonia; See Map 28) Coal and Brown Coal	Areal extent of Brown coal, Iron, Coal, and Manganese. Coal production by districts producing less than one million tons and districts producing less than three million tons. Production centers for phosphorus, mercury, bauxite, Oil-shale also given.
28 Ore Processing and Armaments Plants	Iron-ores, Steel refining ores, Phosphorite, Oil-slate, Blast furnaces and Steel-mills, Blast furnaces, Light metal works, Armament works, Shipyards, Carriage construction. Exact locations given. Classified production.
29 Electric Power Plants (Capacity over 1,000 KW)	Classified into plants of less than 10,000 KW, 10,000 to 50,000 KW and over 50,000 KW.

SERBIA AND GREECE

30 Raw Material Deposits	Areal extent of Iron Bauxite, and Antimony deposits. Centers of production of Coal, Brown coal, Manganese, Chromium, Nickel, Molybdenum, Copper, Lead-Zinc, Antimony and Sulphur ore.
31 Coal and Brown Coal (Lignite) Mines	Classified into: Coal mines up to 100,000 tons, Brown coal mines up to 100,000 tons, and Brown coal mines over 100,000 tons.
32 Ore Processing and Armaments Plants	E-works, Iron ore, Steel refining ores, Sulphur and non-ferrous ores, Steel mill Blast furnaces, Non-ferrous metal mills, Shipyards, Bauxite, Carriage construction. Classified according to importance.
33 Electric Power Plants	Classified as 1,000 to 10,000 KW, 10,000 to 50,000 KW, and Over 50,000 KW.

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LAND-USE PROBLEMS IN CYPRUS

The Proceedings of a Conference on Land Use in a Mediterranean Environment. 55 pp., maps. Government Printing Office, Nicosia, Cyprus, 1947.

This conference on land-use problems in Cyprus, held in Nicosia, April 16–17, 1946, grew out of a study of the Island's grazing problems, and was planned to provide an opportunity for an interchange of views by officers of the governmental departments concerned with land use, representatives of farmers' unions, and others, including visiting officials from Palestine. This report of the conference contains the eleven principal papers presented, together with much pertinent discussion.

The conference was focused sharply on the land use problems found in Cyprus, thus providing an "island" study that would have delighted Jean Brunhes. Here in a restricted geographic frame are found the resource problems that plague the borders of the Mediterranean Sea. Several papers—on land tenure, the development of cooperatives, and the special viewpoint of the farmers—make perfectly clear the bearing of cultural heritages of this particular part of the world, but most of the major conclusions have application in all regions of mediterranean climate.

The discussion turned in the main on the necessity for eliminating free range grazing, particularly by goats. The foresters consider this absolutely essential to the restoration and maintenance of forest cover, the only effective means of soil and water conservation over much of Cyprus. Tree planting near the villages is recommended, but the same restriction on goat grazing is necessary. To limit grazing puts a heavier burden on the arable lands, but provides, in animal manures, one means of maintaining fertility. The unanimous opposition to free range grazing matches the recent decision to outlaw it in the Cumberlands of Tennessee, and points to a conservation principle of world-wide validity.

If the arable land is to bear a larger share in supporting the livestock of the Island, it must become more productive. Evidence is presented that yields are determined by the natural release of plant nutrients in the soil from year to year, that higher yields will require additional nutrients, presumably from mineral fertilizers or indirectly through imported stock feed. "There are no reserves of fertility in the soils of Cyprus." Little hope is held out for increasing the irrigated area through the building of storage reservoirs. The utmost care in protecting watersheds is essential in order to provide enough water for the lands already in use.

For some of the terracing and contouring, the Cyprus Government is importing soil conservation machinery of American design. Americans, in turn, might well benefit from the light which the age-long experience of the Cypriots sheds on land use, particularly in mediterranean and hill environments.

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of the Yellow River plain is similar to that in southeastern New Mexico.[10] The same classification results from the use of the criteria Russell established in his work on the dry climates of the United States, cited previously. The rather low average yearly rainfall amount (15 to 20 inches) makes the extreme rainfall variability menacing to the type of agriculture practiced. Mean annual variability of rainfall on the Hwang plain exceeds 30 per cent; for typical American Great Plains stations between 1890 and 1930 it was around 20 per cent. The low reliability of precipitation in all of north China is associated with fluctuations from year to year in the latitude belt most frequented by the polar front and its cyclones.[11] The BSk climate area on the Hwang plain is subject to the rainfall variability of north China as a whole. In addition, the area lies immediately to the lee of the hill ranges extending from Shantung to the eastern slopes of the Tsinling and opposing any moist tropical airstream from the south or southeast.

There are several factors which may partly explain the incongruity between the Köppen climatic type and the agricultural economy. First, the various formulae for determining the humid boundaries of the dry climates rule that the variation of potential evaporation with the temperature seasons determines the relative efficiency of various rainfall regimes. Vegetation has commonly been used as an indicator of efficiency. Perhaps allowance should be made for what might be called the efficiency, for vegetation, of seasonal concentration. Two factors are at work in the change of the rainfall regime from the Yangtze plain northward to the Yellow River plain. For one thing, there is increased summer concentration, when the temperature is high and the efficiency of the precipitation thereby decreased. On the other hand, this same summer concentration, which permits the dormant season to become arid in north China, tends to keep the growing season humid. The existing methods of identifying dry climates take the former point into account but not the latter.[12] The area might not be comparable to many other BS areas where the rainfall is more evenly distributed among the different temperature seasons, but may be classified with them because of present inadequacies in measuring and describing precipitation effectiveness. In addition to the factor of precipitation effectiveness, another physical consideration is the fact that the Hwang plain is a vast coalescence of low-lying flood plains with a relatively high water table in summer which is only partly dependent

[10] Thornthwaite, C. W., "Climates of North America," *Geogr. Rev.*, Vol. 21 (1931), pp. 635–55.

[11] See Chu, Co-ching, "The Aridity of North China, Its Causes and Consequences," *Jour. of the Geogr. Soc. of China*, Vol. 1, Dec. (1934), (Chinese with English abstract).

[12] For recent quantitative considerations of this problem for places in the United States see Thornthwaite, C. W., in "Report of the Section of Hydrology," *Transactions American Geophysical Union*, Part V, 1944, pp. 686–93; also "The Moisture Factor in Climate," *ibid.*, Vol. 27, Feb., 1946, pp. 41–48, and most recently in these *Annals*, "Climate and Moisture Conservation," Vol. 37, 1947, pp. 87–100.

upon the local rainfall. Probably more important in this instance is the cultural factor of population pressure on the land. The economies usually associated with the dry climatic types of Köppen, especially outside the Orient, might be profoundly altered by a rural population problem such as China's.

The Yellow River plain has, nevertheless, the distinction of being an area where a dense agricultural population farms on an intensive, subsistence basis, mainly without irrigation, in a BS type of climate. Also, this plain—the part of China-proper with the most frequent droughts, the greatest mean annual rainfall variability, and the lowest average annual rainfall—is distinguished by the Köppen classification from the more humid realms to the northeast and south of it which include most of agricultural China.